HURRICANE STORM SURGE RESEARCH

HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

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HURRICANE STORM SURGE RESEARCH

THURSDAY, AUGUST 9, 1984

House of Representatives, Committee on Science and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:44 a.m., in room 2318, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Present: Representatives Scheuer, Andrews, Valentine, McGrath, and Lewis.

OPENING STATEMENT OF HON. JAMES H. SCHEUER, A U.S. REPRESENTATIVE FROM THE STATE OF NEW YORK AND CHAIRMAN, SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

Mr. Scheuer. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order.

Today the subcommittee will examine one of nature's most destructive manifestations, the hurricane. Hurricanes are known for their devastating winds and torrential rains. But the most deadly hurricane force is neither of these. The most deadly hurricane force is the storm surge, an enormous dome of water, 50 miles across and up to 25 feet high, which is driven in front of the hurricane as it approaches land. It can sweep across barrier islands and engulf low-lying coastal areas for miles and miles around.

It was a storm surge that was the cause of our greatest hurricane disaster in our history, the Galveston storm of 1900, in which 6,000 people perished. In 1935, an 18-foot storm surge swept over the Florida Keys resulting in 500 fatalities.

Using a computer simulation of storm surge flooding developed by the National Weather Service, local officials in the Gulf Coast States have recently discovered that the time needed to evacuate their communities far exceeds the 12-hour hurricane warning which is the most that the National Weather Service can now provide under current technology. Areas that have been devastated in the past have alarmingly long evacuation times. For example, evacuating Galveston Island could take 26 to 42 hours. It would take 43 hours to evacuate the Florida Keys.

So it is appropriate that the focus of evacuation studies has been on the Gulf Coast States, and also on the keys. It's increasingly clear that many Mid- and North-Atlantic coastal areas are also at risk.

It is true that in the last 20 years, the North Atlantic coastal areas have been spared from severe hurricane strikes. Ironically, this remarkable reticence, diffidence, restraint on the part of Mother Nature has set the stage for a disaster of major proportions. Perhaps we have been lulled. Anyway, for 20 years the residential and recreational boom on our fragile coastal barrier islands and the coastal areas themselves has dramatically increased the populations of those areas, particularly in the summer hurricane months.

So, sooner or later—the experts tell us—hurricanes will return inexorably to the long-established patterns that time has proven, common in the 1930's and 1950's, of heading up the Atlantic coast. And when they do, we will be rudely reminded that such areas as Ocean City, MD, much of the New Jersey coast, and areas of Long Island in my State and Congressman McGrath's, are candidates for storm surge devastation.

But we really don't know the dimensions of the problem because NOAA, the National Oceanic and Atmospheric Administration, has no more funds to complete studies in these and in other related areas.

So it is critical that we press on for such research, and that we also press on for research into mitigation strategies and planning. One very important area for research is the area of vertical evacuation; that is, sheltering people who couldn't be evacuated, in multistory buildings, in highrise buildings especially designed and adapted to resist storm surge and other hurricane forces.

So I look forward very much to testimony on these important research issues today.

And now, from my fellow New Yorker, the Congressman from Long Island that is very much exposed and will be in the future as I am, representing a portion of Long Island, to these hurricane surge forces, the distinguished ranking minority member of our committee, Congressman Raymond McGrath.

STATEMENT OF HON. RAYMOND J. McGRATH, A U.S. REPRESENTATIVE FROM THE STATE OF NEW YORK

Mr. McGrath. Welcome to the South Shore, Mr. Chairman.

Mr. Scheuer. Thank you.

Mr. McGrath. I want to thank the chairman and join the chairman in welcoming our witnesses here today.

As the chairman said, I am a Representative from the South Shore of Long Island, an area which is on the front zone of hurricanes, and I am very interested in the subject of our hearing this morning. Although the hurricane of 1938 was about 2 or 3 years before my time, it stands out as an example of the devastation that can be wrought by a hurricane, and also as an example of the vulnerability of Long Island to such severe storms. As I am sure all residents of coastal areas would agree, we must not be lulled into a false sense of complacency because we have not been hit by a major hurricane in several years.

I am particularly interested in hearing what our witnesses have to say today about recent research in the area of vertical refuges. This idea is a new one to me, and I'll be interested in seeing how a tall building should be considered a vertical refuge. In my congressional district on Long Island, which abuts along the South Shore of Nassau County, we don't have many buildings that are over six or seven stories high, and I am wondering how these could be considered adequate vertical refuges. Also, considering the density of the population on western Long Island and the shortage of tall buildings, I question whether these refuges, if proven effective, would be a viable option.

There is one recent occurrence which makes the issue of hurricanes and evacuation plans even more timely, and that is the recent failure of our GOES-East satellite. I was extremely disturbed to hear of the failure of this satellite, which provided us with coverage of the hurricane-spawning ground off the coast of Africa. It was this coverage which provided us with much of the early warning capability for hurricanes. I will be interested in hearing the comments of our witnesses on the failure and also on ideas to prevent this unfortunate situation from recurring in the future.

Mr. Chairman, I thank you for having this hearing. It is a timely hearing as we enter the hurricane season. Something should be done, and we are happy that the subcommittee has made the effort in this behalf.

[The prepared statement of Mr. McGrath follows:]

STATEMENT OF HON. RAYMOND J. MCGRATH

Thank you, Mr. Chairman.

I want to join the Chairman in welcoming our witnesses here today.

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Thank you, Mr. Chairman.

Mr. **ANDREWS**. Thank you, Mr. McGrath.

At this time I would recognize Congressman Lewis.

STATEMENT OF HON. TOM LEWIS, A U.S. REPRESENTATIVE FROM THE STATE OF FLORIDA

Mr. **LEWIS**. Thank you, Mr. Chairman.

I am particularly pleased that the subcommittee is taking a close look at hurricane storm surge research today. Since my Florida congressional district includes both the South Atlantic and the gulf coast, I strongly support this subcommittee's initiative in monitoring hurricane research. I believe that it is important that we make the results of this research fully available; not only to all State and local agencies responsible for implementing emergency plans, but also to the general public for their education.

Given the general and tremendous growth of real estate development and the rapid increase in population along south Florida's coast, we have been lucky in recent years to have escaped the widespread destruction of life and property caused by hurricanes. However, in spite of the increasing vulnerability of the Florida coastline, residents have grown complacent. Many residents, new since 1960 when the last big hurricane hit and moved through the State, and that was Hurricane Donna, have never experienced anything like a killer hurricane. And I guess we never can forget Camille that went into Louisiana.

These people have no idea what to expect and how to prepare for a hurricane. By virtue of its geography, Florida is, in my opinion, the most susceptible State to hurricane weather; and that is why I look forward to hearing Dr. Frank of the National Hurricane Center in Miami and our other two witnesses from Florida, Dr. Spangler of the University of Florida and Dr. Baker of Florida State University. I am particularly interested in the comments of Dave Murray from "Good Morning, America" whom I heard this morning. I am particularly interested as to how they would assess the current research in this field.

This is something, Mr. Chairman, that I am very much concerned about in my calls throughout the State and my district. In my judgment, there is not sufficient concern as to what could happen with a storm surge or if we had a Donna or Camille hit south Florida.

In addition to how well prepared the State of Florida feels it is, we would suffer severe consequences if we had a storm of a killer nature here in the very near future.

Thank you, Mr. Chairman.

Mr. **Andrews**. I personally want to say that I am very delighted to have Dr. Frank here today. In the aftermath of Hurricane Alicia last summer, this subcommittee held hearings in Houston along with the Subcommittee on Public Works on this whole issue of preparedness, vertical refuge, FEMA and their jurisdiction, I think with some success. I'm very pleased that we are able to take up this issue again, especially as we near the 1 year anniversary of Hurricane Alicia.

You know, one of the things I think that we learned in that hearing is how fortunate the people in the gulf coast really were, and the dire consequences that I think we face on the Atlantic seaboard and in the gulf coast due to hurricanes. The issue is not whether or not we're going to have a five-rated hurricane, but when we're going to have one and where that hurricane is going to strike.

And so issues like vertical refuge, issues like evacuation techniques, and the ability of FEMA to adequately respond to these disasters, I think are important questions for this subcommittee to be addressing and I'm pleased that this morning we have the witnesses we have.

Without any further opening statement, our first witness today is Dr. Neil Frank, Director of the National Hurricane Center, National Weather Service.

Dr. Frank, if you would please take the witness table.

STATEMENT OF DR. NEIL L. FRANK, DIRECTOR, NATIONAL HURRICANE CENTER, NATIONAL WEATHER SERVICE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Dr. **Frank**. Mr. Chairman and members of the subcommittee and staff members, I appreciate this opportunity to come before this subcommittee again, and I appreciate the interest that you have, of course, in the hurricane problem.

Your staff had suggested that maybe it would be useful today that if we would take a quick look, visually, at what can happen along the coastline when a bad hurricane comes—and I can think of no better example than Alicia—so, Congressman, if you'll allow me, I'll go ahead and use some of the pictures that we got from Alicia this last year to illustrate, I hope, some of the points that I think are so important for this subcommittee to consider.

Hurricane Alicia was almost the meteorological nightmare that we've come to fear. By that, I mean that we have a weak hurricane approaching the coastline; we notify the community that it is a weak hurricane; they take some action, but they don't get everybody back to high ground that is now vulnerable. And then, in the final hours before landfall, significant strengthening occurs and the storm arrives much stronger than we anticipated, and now you don't have enough time to go ahead and get the rest of the people back to high ground.

Now, the saving grace in the case of Alicia was a 15-foot seawall that is located in front of the city, built there after the great hurricane of 1900 that killed 6,000 people. So as the water begins to rise, many of the people hustled in behind the seawall and took refuge in the hotels. A lot of them ended up in the Galvez Hotel because, after all, the Galvez Hotel had had quite a reputation for hurricane parties down through the years, and this seemed like a good place to go. But what they didn't anticipate was that some of the windows were going to blow out, and then the interior walls collapsed. Panic set in, and many of those—well, all of the people in that hotel, eventually—ended up in the basement.

Now, can you imagine the tragedy that could have occurred there if Alicia would have continued to strengthen, and then the water would have topped the seawall and come down in the basement where all the people were? They did have problems behind the seawall; they did have some roof damage; they did have some trees blow down, but essentially, there was no loss of life.

Now, we were most concerned to see what's happening out ahead of the seawall. You see, down through the years the sand has drifted toward the east on Galveston Island, and a big, huge sandbar has collected out in front of the seawall. The white ribbon you see through the center of the picture is the seawall, and you've got 400 or 500 acres of land in front of the seawall and we're now building condominiums out there.

Now, this condominium was located there during Alicia. The storm surge came in through the ground floor, destroyed the walls in the recreational room, but the integrity of the building survived. One thing they did learn, though, is that sliding glass doors don't hold out much water. So the wind-driven rain came through those sliding glass doors, and they had flooding from the top floor to the bottom floor, but the integrity of the building survived.

Also, another condominium that I understand has now been finished, about 200 yards to the east of the one I just showed you, also went through the storm. You can look over here to the right and you can see how the water undermined portions of that building. You can see where the sand was eroded, but it was on pilings and the building did survive.

The concern I have is that we may now be led to false conclusions—"Aha, we must know how to build the buildings, because after all, these two survived."

Now, on this Safford-Simpson hurricane scale, a rolling scale of 1 to 5, Alicia strengthened from a 1 to a 3. It wasn't a 4 or a 5, and I'm not sure with a 4 or 5, but what we wouldn't have seen some damage to those buildings. So I am concerned that we might not want to go ahead now and develop that whole area out ahead of the seawall. As a matter of fact, I've seen in the newspapers this last year plans to develop 440 acres of that tract out there.

Now, on the western end of Galveston Island, where they didn't have a seawall, things were a bit different. Notice this two-story house, down here in the right-hand corner? It's a two-story house, built on pilings, floor level 11 feet above mean sea level. Eight to ten feet of storm surge came through this area, and the only thing left of that house after the storm went by was the three pilings you see over on the left-hand side and a little bit of the roof out in the surf zone, and a sign that said that at one time the Dennises lived in that particular house. The house was built by an architect couple out of Houston for $240,000 the year before the storm hit.

Now, adjacent to that house—you see that house again, in the top of the picture—a series of beachfront homes, vegetation line well out in front of those homes. All right. The storm surge comes in, excavates 5 or 6 feet of sand, moves the vegetation line all the way back to the road, exposing a seawall around this home here that you see on the left. And when residents came back the next day to inspect their property, if they didn't bring a stepladder they had a tough time reaching the front door.

Another example of the movement of the sand dune during a hurricane took place at Jamaica Beach. Now, you see there was a 15-foot sand dune in front of these two homes there; you can see the little walkover on the left. The storm surge moved in and moved that vegetation line all the way back to the road.

They have a fascinating law in the State of Texas. It says that the State owns all of the property ahead of the vegetation line. Who owns that home on the right, over here? And the State's claimed it; and I understand that, in the first round of court hearings, that the State has won and that the owners of that particular property have lost.

A two-story house, 11 feet above mean sea level, on pilings, behind the sand dune before the storm—the only thing that was left after the storm was the three pilings you see over here on the right-hand side.

Now, what was the problem? It was storm surge. Everybody knows that hurricanes are big wind; everybody knows that hurricanes can have a lot of the rain and inland flooding. But it's the storm surge that we worry about, and most people don't really understand what that is. A storm surge is a dome of water, maybe 50 miles wide, that sweeps across the coastline near the point where the eye of the hurricane makes landfall. The bottom line here that you see, the horizontal line, is sea level. In this particular illustration we have a 15-foot storm surge; the water is raised that high, and then the big waves come in on top of it.

Here's a good example of what the storm surge looks like. The island is literally under water, and the waves are breaking around the tops of the trees. Now, you put a building out there, and where are the waves going to break? Right against the sides of the building, and the building codes that we have in this Nation do not address moving water. They give us a measure of protection against wind and wind alone.

Back to the western tip of Galveston Island. It's kind of interesting. Notice on the right-hand side, there was a series of pilings there? I took this picture in May, before the storm. From May to August, that building was completed and then washed away by Alicia. Now, what was the problem here? Well, let's take a look at the pilings. The pilings were too short. I found in many cases they were only putting pilings down 4 or 5 feet; and then, of course, the storm surge comes in and excavates 5 feet of sand, and there's nothing to hold the building up.

There were also inadequate building codes. In south Florida we call these "hurricane clips"; we use them to tie our roof to our walls. In Texas, they were using them to tie the building to the foundation, and that just wasn't adequate.

Three homes here on the right—and again, one that hadn't been completed in May; it was completed before the storm—the impact of the storm surge is well illustrated, I think, in this slide. Because, you see, the water comes in, excavates sand out from underneath the foundation; as the water rises, the waves hit the front of the building and then, perhaps, that weakens it enough that the wind can take the roof off.

We learned a fascinating lesson here in this first home, up here on the right-hand side now—we found out that window shutters work very well. Now, if we could get the walls to be as strong as the window shutters, maybe we could solve the hurricane problem.

Downtown Houston—this building in the foreground, the Tenneco Building, had come under a lot of criticism because there are experts that said the wind went over the top of that building and picked up gravel and knocked out all those windows in the building there in the background. And that probably happened in some cases; but it doesn't look like to me that that window that you see fallen, there, is broken. This one somehow got blown out and there was another problem there. Furthermore, I would suggest that gravel doesn't have enough intelligence to be selective and just get every other row of the buildings.

Well, those windows, I understand, cost $2,000 and weighed 500 pounds, and there were literally thousands of them in the street after the storm went by.

What about the rebuild? Notice this house over here on the right-hand side? The seawall was destroyed, excavated 5 or 6 feet of sand out from underneath the foundation. I landed and went down to the coast a few days later, and this was the scene. They already had the seawall rebuilt, and it was filling back in. I talked to the contractor and I said, "Tell me about this." And he said, "Neil, you just keep bringing them hurricanes along and I'm doing all right. This is the third time that I've had to fill that property in since 1980."

Now I thought that it was fascinating recently that I was down there and found out that they've got a brand-new condominium that is going in just to the west of the seawall. You could go down there and throw a stone over and hit the west end of the seawall. And the advertisement on this building is, "You don't have to live behind the seawall," as if the seawall was some kind of a bad thing—"you can live right on the ocean."

Well, what have we learned in other areas where we've had bad hurricanes? Hurricane Frederic, 1979, went over the Alabama coast, a category 3 storm. Twelve feet of storm surge. This was a beach house condominium, three story structure, ground floor parking, main living area 11 feet above the mean sea level so you had your main living area on the second floor; third floor was bedrooms. Twelve feet of storm surge came in, and this was the result.

Now, I had a friend who was part owner of the second unit in there on the left-hand side, but he was one of the lucky ones because he sold his interest out to his sister-in-law before the storm. And I asked my friend Rick if his sister-in-law was still speaking to him, and he said, "Listen, you'll never guess what she's trying to do." And I said, "Well, try me." He says, "Well, she wants to buy the unit on the wing when they rebuild." Rebuild, 1982, and my friend's sister-in-law owns the two units on the left-hand side. Then we had some winter storms in 1982, destroyed the seawall and undermined her particular unit; it wasn't even 1 year old, and here it is being undermined again.

Now, what's the problem? Let's go airborne. Please note where the beach is retreating: right where we built a seawall. When we put a seawall down there, we interrupt the natural cycle and then human beings end up losing. In the natural cycle on a day like today, the wind blows, picks up the grains of sand, builds up a sand dune. Then one day a storm comes along; the water rises, the waves reach up, grab the sand on the dune, and then when the storm goes away it spreads that sand back across the beach and you've still got a beach, and then you start through the cycle again and the dune rebuilds again.

I want to point out to you that the dune doesn't know anything about high water lines and vegetation lines and property, though, and the dune may be 100 yards further in next time or it may be a little further out to shore. You just never know. You put a seawall there, then when the storm comes by the water rises; the waves reach up to grab the sand on top of the dune and there is none, so it just takes the sand from out in front of the seawall.

How about looking to the west? That inlet wasn't there before the storm, but the storm created that new inlet. They couldn't get those cement trunks out there fast enough to make it permanent because a lot of the folks on the right-hand side, on the lagoon side, had been wanting an inlet for a long time so that they could get out and go fishing.

Now, there's a natural migration of the sand from the east to the west, and these folks down in the lower part of the picture here are just ecstatic. Look what their beach is doing. Every year it's growing. But how about those folks up there in the top of the picture? They're not excited at all about this whole sequence of events because the beach is now back underneath their property. That second house on the left-hand side went on the market for $189,000 in the fall before the winter storms caused all this beach to retreat, and the beach is now back underneath their property; about 5 or 6 feet of sand has been excavated there. I never cease to be amazed at what people do to protect their property—going to put a seawall out there and hold the Atlantic Ocean back.

Let me predict what's going to happen to that seawall. Same thing's going to happen to that seawall that happened to this swimming pool in Sand Bridge, VA. The owner here decided to build a swimming pool one day, and so they did. Well, the city came by a few days later and found out that he had that swimming pool there, and said, "You can't do that; that's against the city ordinance." So they took him to court, and before they could render a decision in court, nature imposed its own solution; it just washed that swimming pool right away. The pool was in front of that home that has the blue deck, there.

Now, back on the Alabama coast again, the Chi-Chi Restaurant there on the left—I call your attention to the palm trees, because that was all that was there after the storm went by. The owner of this property has now sold it off to a developer who is now locating a condominium there. Before the storm there was not one multistory condominium at Gulf Shores; there are now 15, and would you please look at this development here? They've walled in that beachfront home there. See the beachfront home between those two condominiums? All kinds of interesting things take place in the aftermath of a storm, and a whole bunch more foundations are being poured. So 15 condominiums, and a whole bunch more being built—a place that was not a problem for us before the storm because you could evacuate everybody in 3 or 4 hours has all of a sudden become a problem for us because we may not be able to provide enough leadtime to get everybody out. That raises an interesting question.

Can we get everybody back from the coastline in the leadtime that I can provide in the warning? Well, we've completed some comprehensive evacuation studies in a number of places, and I want to touch on that real quickly. Comprehensive evacuation studies means you've got to consider your neighbors when you do your evacuation planning, because they're going to use the same inland roadways that you use. There are five steps in a comprehensive evacuation study. First of all, you've got to know what part of your community is going to be flooded. We can do that with these numerical models that the chairman mentioned in his opening statement.

The second thing you need to know is how many people live in those areas to be flooded? Well, we can go to the census figures and do that.

The third thing you need to know is, what are the people going to do that are living there? In other words, how many people are going to use the option of going to a shelter? And once you know how many people are going to shelter, then you've got to locate enough shelters so that those people can be housed.

Now, finally, you can give this whole thing to traffic engineers and they can tell you how long it's going to take to complete your evacuation. When you do that, this is what the results look like at a number of communities. The only reason I show these communities is that this is the only place that these kind of studies have been done, and you can see—the results are frightening. It takes 20 to 30 hours to get everybody back to high ground in these locations.

We have completed studies in Corpus Christi, Port Arthur, and—I believe—Charleston's is about completed now. But we don't know what the time is in the New Orleans area, and certainly we don't know what the times are up along the eastern part of the United States, and that really concerns us because we desperately need to complete those kinds of studies.

The evacuation times here, the clearance times, assume a couple of things. No. 1, it assumes that everyone's going to respond when you tell them to; and, furthermore, that they know that they're in danger. And we have no reason to believe that they know that. For example, in Long Beach Island, NJ, I understand 150,000 people will be out there on a normal summer weekend. There's one four-lane highway that goes out of there. Now, you can use three lanes to move traffic off; traffic engineers say that you can move about 500 cars per lane of traffic per hour. If you use three lanes, that's like 1,500 cars—maybe, at the most, 2,000. How many people are you going to put in a car?

You don't have to complete a comprehensive evacuation study to know that it's going to take 15, 20, 25 hours to get everybody off of that particular island.

How about Atlantic City? I wonder if the people really know what their dangers are here? In Atlantic City, at the lower part, Absecon Island, southern end of Brigantine Island in the upper part—now, down through the years they've had a problem because there's a natural migration of the sand from the north to the south, and it kept filling in that inlet. So they went to the Corps of Engineers a few years ago and said, "Can you solve the problem?" And they said, "Sure. We'll put you a jetty up there." And they did so, and then this huge sandbar is collecting on the north side of that jetty. They sold the property off to a developer within the last several years, who is putting up 300 or 400 homes out there.

I went down to city hall and said, "You got a problem, a hurricane problem, here?" They laughed and said, "We've been here 40 years and never had a problem." And then I bought a history and found out that in the 1800's, three severe hurricanes moved whole sections of the island. And yet they don't have a hurricane problem on Brigantine Island?

Another interesting example of the lack of awareness is this little community down near Myrtle Beach in the Carolinas. The most vulnerable part of the coastline is the barrier island; the most vulnerable part of the barrier island is the inlet. Put a little seawall around here—if you remember seeing on TV over the last year or so, Phillips Petroleum was advertising this way of making seawalls hurricane-proof. In other words, if you took this little piece of plastic and put it behind that seawall, then it would be hurricane-proof; and this was one of the examples that they showed there. I wonder if the folks that live out there really are aware of how dangerous it is to live there. I wonder what their developer and their real estate people told them when they sold them the property.

Let me tell you a little bit about that man. The man who built those townhouses out there also built this series of beachfront homes and sold the property and built the homes for the people who own them today. But he was a very astute real estate man, because he put in the contract that if there was any accumulation of sand beyond the high water mark at the time of the sale, it was his, not theirs. And he's been one of the fortunate ones. A lot of sand has accumulated there, enough so now that he can make out—carve out new beachfront lots, and he's got them for sale.

The homeowners took him to court over it, and the judge ruled that if they wanted to continue to have beachfront property, they were going to have to buy the new lots from the guy who built their houses.

Now, over at Wrightsville Beach, the folks that live in these apartments to the right and this hotel, they keep wondering why they can't keep a beach there. Well, I can tell you why. In 1954, Hurricane Hazel put a new cut through there; and then the sand, of course, filled back in, but then they have a problem keeping the beach there. There's no pilings underneath this condominium that sets on Lyndhaven Inlet just inside of the Chesapeake Bay.

Fire Island—I didn't think that there was a problem there because, Congressman, they told me that nobody lives out there permanently. And then I flew along there a couple of years ago, and I said, "Well, if nobody lives out here permanently, what are all those houses?" I found out that this is a weekend retreat, and people have to come out there—I believe, if my information is correct—have to go out there by boat. And I said, "Well, how many people are out there on a weekend?" There are 12,000, and you've got to get them out by boat. Can you believe that? A place that we didn't even know about!

Now, the second thing that you assume, on those clearance times that I showed you, is that my office is going to provide you that kind of leadtime. Let me show you a couple of examples of where it would be very difficult to give you the 20 and 30 hours of leadtime.

In 1954 we had a hurricane by the name of Hazel off of the Bahama Islands; 24 hours later, it crossed the Carolina coast as one of the worst hurricanes that they've ever experienced. In Long Beach Island—and now I'm talking about North Carolina, this is just west of Wilmington—there were 357 beachfront homes before the storm. After the storm there were only five. All the rest of them were washed away.

Maybe the most frightening example I can give you is the 1938 storm. Again, a major hurricane off the Bahamas, and in 30 hours it crossed Long Island—it was maybe the worst hurricane that we've ever had in the northeastern part of the country.

In Westhampton Beach, I believe that's where this picture was taken, there is a series of rather large and rather substantial beachfront homes. You can see one fence line here—if you'll look at the second fence line, notice the post over there? Because after the storm, that's all that survived. You can see two of the posts on the fence there.

And downtown Providence was a disaster area. There was flooding all over in the downtown area of Providence.

Well, as a result of that storm we built hurricane gates across Narragansett Bay and Buzzard's Bay. Fortunately we haven't had to use those too many times down through the years.

Now, the closing remark that I'd like to make is this. The saving grace, in case of Alicia, was a 15-foot seawall, but we don't have 15-foot seawalls along many of our barrier islands in the Northeast; Fire Island would be a good example, the Jersey coast, on down through the Carolinas and certainly down into Florida. And if we had one of these unexpected meteorological surprises like Alicia, we're just not going to be able to provide the leadtime that the evacuation studies are now indicating will be needed to get everybody out. And we desperately need to move on quickly in this country with some kind of plans—alternatives, maybe—to moving everybody horizontally back to high ground. If we don't do so, I fear that we're going to pay the price one of these days in the loss of hundreds, and maybe even thousands, of lives.

I appreciate the opportunity of sharing with you this morning.

[The prepared statement of Dr. Frank follows:]

STATEMENT BY

DR. NEIL L. FRANK

DIRECTOR, NATIONAL HURRICANE CENTER

NATIONAL WEATHER SERVICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH

AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

AUGUST 9, 1984

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to participate in the Subcommittee's study of preparation necessary to protect residents from harm in the event of a major hurricane.

First, I would like to assure you that in my opinion hurricanes are not part of nature's plan to inflict death and destruction on humans. Naturally, that is the way we evaluate the impact of a hurricane -- how many died and what was the dollar loss? However, hurricanes perform a very positive function in the atmosphere.

The earth receives too much heat in the tropics and not enough heat in the polar regions because of the angle of the sun's rays.

In order for this planet to be tolerable for life, the cold and the warm air must be mixed. Nature has a very effective way of accomplishing this task in the summer and it is the hurricane. When a hurricane forms, it actually represents a kind of "boiling" of the tropical atmosphere, and when it moves into higher latitudes it moves heat from the tropics.

If humans would learn to live in harmony with nature, we could minimize our dangers. For example, if you live in California and build your home on a fault line, don't fuss about earthquakes. Likewise, if you build your home on a barrier island in New Jersey, or the Carolinas, or Florida, or Texas, don't complain about hurricanes. I believe hurricanes are supposed to sweep by our coasts every few years. I am not sure it was ever intended that people should locate on the barrier islands. But, we have decided to do so, thus, we now have a very serious hurricane problem. I submit the problem is primarily a human one.

This raises a very serious question. Can we respond effectively to a hurricane within the warning lead time available?

Before we examine this question, let us briefly explore the dangers associated with a hurricane. There are three aspects of the hurricane that we need to consider. First, hurricanes are "big wind" and wind can cause considerable damage. In 1970, Hurricane Celia caused $453 million in damage in Corpus Christi, Texas, and most of this was wind damage.

A second aspect of the hurricane is heavy rains, which produce inland flooding along rivers, creeks and low lying areas. The remnants of Tropical Storm Agnes caused over $2 billion dollars in damage, primarily along rivers in Pennsylvania.

However, neither the wind nor rains significantly threaten great loss of life. The most feared part of the hurricane is the storm surge, and behavior studies show this aspect of the hurricane is least understood. Nine out of ten people who die in hurricanes drown in the storm surge.

The storm surge is a dome of salt water nearly 50 miles wide and 10, 15, or even greater than 20 feet high that sweeps across the coast near the point where the eye makes landfall. It is water well above normal levels topped by huge waves. Barrier islands become completely inundated and the damage caused by continued wave action can be awesome.

We don't have to speculate about what a major hurricane can do in the United States because history offers many spectacular examples.

In 1938, a major hurricane crossed eastern Long Island and then moved into Southern New England. There were 179 homes in West Hampton Beach before the storm. Only 26 remained after the sea subsided. Today, there are more than 900 homes in that same area.

Hazel, in 1954, devastated the North Carolina coast. There were more than 300 homes on Long Beach (west of Wilmington) before the storm; only 5 survived.

In 1893, two severe hurricanes struck the U.S. One pushed water over 20 feet high across the barrier islands along the

Georgia and South Carolina coasts, killing in excess of 2,000 people. Hilton Head Island was completely inundated. Nearly 20,000 people live on Hilton Head today. Another 1893 hurricane killed 2,000 plus on the Louisiana coast in the vicinity of Grand Isle.

The stongest hurricane in U.S. history swamped the central Florida Keys with 18 feet of storm surge in 1935 and killed 500 people. Today, 75,000 live on the Keys.

In 1848, a hurricane produced 15 feet of storm surge in Tampa Bay. Water completely covered every barrier island, and most of the inner bay peninsula, destroying Fort Brooks where downtown Tampa is currently located. Water was 8 feet deep where a major hospital is located today. Nearly 100,000 people inhabit the barrier islands.

Frederic, in 1979, was the costliest hurricane in U.S. history, causing $2.3 billion in damage to the Alabama coast. There were very few multi-storied buildings in Gulf Shores before the hurricane. Today, 15 major condos have been completed and many more are under construction.

The Galveston hurricane of 1900 was the deadliest natural disaster in the Nation's history. Water inundated the entire island and killed 6,000 people. In order to prevent this from occurring again, a 15-foot seawall was constructed in front of the city. Even though the seawall has worked well for over 75 years, it hasn't done much for the beach. A lot of the sand has drifted eastward and formed a huge sandbar on the southeastern tip of the island ahead of the seawall. Condos are now being constructed on this sandbar ahead of the seawall. In addition, major developments are being built on the western half of the island beyond the seawall.

With this brief overview of hurricanes, let us now return to the original question -- Can the nation respond to a hurricane warning? For example, how does one escape the storm surge? If you live on a barrier island and a hurricane threatens, you should get in your car and evacuate inland to high ground. Is this possible? Recently completed comprehensive evacuation studies raised serious doubt whether horizontal evacuation can be completed within the lead time we can realistically provide.

Comprehensive evacuation studies consider not only the community, but also the impact on your neighbors. An evacuation study of Lee County, Florida (Ft. Myers), can be used to illustrate the importance of comprehensive planning.

We have never worried about Sanibel Island because traffic engineers have told us for years that the 10,000 residents can be moved inland in less than 10 hours. The "comprehensive evacuation" study confirmed this conclusion. However, if you also evacuate Fort Myers Beach, Pine Island and other vulnerable locations, the evacuation time rises to 18 hours because of traffic congestion.

This result created enough concern that it was decided to expand the study for six counties extending from Sarasota to

Naples, including two inland counties that will be impacted by the evacuation. The evacution time increased to 27 hours.

Similar studies for Tampa Bay show 18 hours for evacuation. It will take 26 hours to evacuate Galveston Island, nearly 30 hours for the Florida Keys, over 20 hours for the southeast Florida coast and approximately 21 hours for Hilton Head Island, South Carolina. The evacuation time for Hilton Head Island will become 54 hours by the year 2000 with the projected population increases unless new bridges are constructed.

We don't even know the time required to evacuate most locations along the highly populated east coast because comprehensive evacuation studies have not been completed. But reasonable speculation is frightening. For example, we know over 100,000 people will be on Long Beach Island, New Jersey, on a summer weekend. The only way out is two lanes of a 4-laned causeway. Traffic engineers tell us you can move approximately 500 cars per lane of traffic per hour. The evacuation time is a function of how many people will be in each car. Even with an optimum of five people per car, it will take over 20 hours to move everyone off the island. With a fast moving storm like the 1938 hurricane, we might not be able to provide more than six hours lead time for evacuation.

There is a weekend retreat on Fire Island, New York, that accommodates approximately 12,000 people. The only way in or out is by boat!

Our goal at the Hurricane Center is to provide 12 hours daylight lead time for evacuation purposes. The numbers don't add up. We now know it is going to take much more lead time for evacuation in several localities than the technology of hurricane forecasting can provide, and we have no reason to believe the problem will be less severe in other highly populated coastal areas. There is an urgent need to complete comprehensive evacuation studies for all coastal locations within the U.S. so we can identify the totality of the hurricane problem.

What is the answer? One of the first things that comes to mind is to improve hurricane forecasting. Is this possible?

Hurricane forecasting requires two important pieces of information. First, one needs to know about the event, and second, one must adequately describe the steering currents that control hurricanes.

There have been dramatic improvements over the last three decades in our ability to observe hurricanes. We now see the entire Atlantic Ocean, the Caribbean Sea and the Gulf of Mexico every 30 minutes day and night through the eyes of the weather satellite. If a potential hurricane is spotted on the satellite pictures, weather reconnaissance aircraft are launched to probe the inner core of the hurricane. Finally, as the hurricane approaches the U.S., a net of coastal radars monitor its minute-by-minute progress. Even with these excellent observing tools we can still be surprised by an unexpected coastal development; but it is reasonably safe to state that a major hurricane today would not cross the U.S. coast unannounced. Satellites, aircraft and radars are excellent observing platforms, but that does not tell us where a hurricane is going.

The steering currents that determine the destiny of hurricanes are controlled by the large high pressure areas that dominate the oceans during the summer. If you want to make more accurate hurricane forecasts, you must have reliable weather observations over large expanses of the Atlantic Ocean, but this is probably not feasible from an economic point of view.

Another course of action would be to build protective barriers along the coast. For example, a hurricane gate was constructed across Naragansset Bay after the 1938 hurricane to protect Providence. Although this might be effective in some areas, most coastal residents would find it totally unacceptable because it would destroy the view of the ocean. Furthermore, it would be very expensive.

Perhaps it is time to seriously consider alternatives to existing preparedness planning. Comprehensive studies raise considerable doubt about the feasibility of horizontal evacuation in some locations. If we don't evacuate everyone to safety, maybe people could relocate away from the water to the upper floors of well-constructed condos, hotels, or other multi-storied buildings. This concept is known as "vertical refuge". There is evidence that large buildings located several hundred feet inland from the high-water line or back on the bays or inland waterways would survive a hurricane. Policies could be initiated that would make "vertical refuge" practical.

We are more vulnerable to hurricanes in the U.S. than we have ever been in our history. Hundreds of thousands of people now live on our beautiful barrier islands, and evacuation studies show we may not be able to move everyone to the safety of higher ground in the lead time available in the warnings. The good news about bad hurricanes is that they are rare events, but this fact has lulled the nation into complacency. The impact of a major hurricane will be catastrophic and this can't be ignored.

If a major hurricane strikes a highly developed coastal location sometime in the near future, the loss of life could exceed the 6,000 lost in the Galveston hurricane.

Mr. Chairman, this concludes my prepared statement. I will be happy to answer any questions.

Mr. SCHEUER. Well, we very much appreciate your very thoughtful and somewhat disturbing testimony. I suppose you had in mind that it might be disturbing, and it certainly was.

Congressman McGrath, my colleague from Long Island.

Mr. MCGRATH. Thank you, Mr. Chairman.

That was quite a presentation. In my opening remarks I alluded to the failure of one of our satellites, and in order to compensate for that we're going to be moving the western satellite over toward the middle of the country, hopefully to take over the area that's being missed. But certainly, we're going to be missing quite a bit of coverage.

How much of a problem is that for you and where do you start tracking? Where do you start seeing the beginnings of these things that you need? With the loss of this satellite, do you have to pick them up at a later date, or what?

Dr. FRANK. OK. We follow about 100 tropical disturbances a year, and over 50 of these have their origin over Africa. Historically, we've tracked them across the Atlantic Ocean with the satellite, through the eyes of this GOES-East satellite that has now failed.

We have other observing systems, though. We do have reconnaissance aircraft that we can use; and, of course, if you go back prior to the satellite, that was our primary way of surveying that area well east of the islands.

When we move the GOES-West satellite over to a central location in the United States, we're not going to be able to see as far East as we were able to with the GOES-East satellite. However, we do plan to supplement this limited view with an increase in reconnaissance flights, and the Air Force is prepared to do that for us.

Mr. MCGRATH. Well, are there any plans to use Defense Intelligence satellites and others to supplement our availability of——

Dr. FRANK. Yes, sir. And there's two ways we orbit weather satellites. One is that we orbit the weather satellite around the equator; and if you put the satellite high enough above the Earth, like

22,000 miles, it rotates at the same rate that the Earth rotates. Now, that's a tremendous advantage to us in the tropics because we're seeing our tropical areas. And that's what we were using the GOES satellite for. But you can also orbit satellites over the pole; and as the Earth rotates, you see a different strip of the Earth every time that the satellite makes its orbit. The Defense Department utilizes this kind of an orbital characteristic.

Now, we will have available to us information from that satellite, and so we plan to supplement our own NOAA weather satellites that are polar-orbiting with the satellite information that comes from the Department of Defense, and particularly, we're just going to be flying more missions.

Mr. McGrath. All right.

You didn't say it, but during your testimony you have given me the impression that you think this vertical refuge idea——

Dr. Frank. No, no, no, no, not at all. I'm one of the ones who has indicated that that may be the only alternative. See, I'm willing to listen to any other alternative. We know this, that when the storm surge comes over the barrier islands, the barrier islands are going to go under water. What alternatives do you have? You don't have many. You've got to get up someplace, and I think that if you get back away from the waterfront—I'm not proposing we put people in the buildings right on the waterfront, because the only thing you know about that building is how it has been engineered. You don't know how it's been built, and we have enough evidence in the aftermath of some storms that the building techniques that were used there weren't adequate, and they certainly weren't consistent with what the plans call for. So I'm not advocating that we put people up in buildings right on the waterfront, but couldn't we go back on the inland water areas, or back into the interior of the barrier islands, encourage development of condominiums there, and then we could take people up into the interior hallways of the upper floors of those condominiums and at least they would survive?

Now, it's fraught with legal problems, and I understand that—maybe some of the others who will testify here today would like to explore the legal problems—I know that Dr. Baker has looked into that aspect some.

Mr. McGrath. All right.

During your testimony, I was just envisioning what might happen in my own district——

Dr. Frank. Yes, sir.

Mr. McGrath. Where there is a barrier island called Long Beach and Atlantic Beach; it's less than a half a mile wide, probably has 45,000 residents, and two two-lane bridges. It's incredible what could happen in a situation like that.

Thank you very much for your testimony.

Mr. Scheuer. Just elaborating on what you're saying, up until a year and a half ago I represented the Rockaways in New York. The Rockaways is a little strip of land; it attaches to Long Island but, for some reason, it's labeled Queens. It has two bridges that give it access to Queens and one road that gives it access to Long Island, and there's 130,000 people that live there. When we have a pleasant Saturday or Sunday in the summertime, and maybe we have a rock band concert out at Riis Park, it's impossible to get in or out of the Rockaways. If there's a fire or a medical emergency, there's a potential of enormous human tragedy and suffering. It's hours before you can get across those bridges—many, many hours—and if, God forbid, there were a hurricane there—well, you're talking about not 5,000 or 10,000 people on that one barrier reef, you're talking about 130,000 people with one road and two bridges.

Congressman Mike Andrews of Texas.

Mr. **Andrews**. Thank you, Mr. Chairman.

Let's follow up a little bit on this line of questioning and let me ask you to be specific about Hurricane Alicia, to use an example, and to kind of underscore what both of our colleagues have just suggested.

In your testimony you stated that what Galveston had was a 15-foot seawall and, thank goodness, they had that seawall there. But something else unique happened about Hurricane Alicia, and that is the followup rain, the 6 to 10 to 12 inches of rain, did not occur. Like the chairman's district, Galveston Island is connected by one long artery, and I wonder if you would just comment, based on your testimony also that it takes 20 to 24 hours to evacuate Galveston Island, what would have been the consequence, even with the seawall, had we gotten 6 inches or 8 inches of heavy downpour?

Dr. **Frank**. Congressman, I don't think that that would have had that much impact in terms of potential loss of life. You know, the heavy rains on an island like Galveston are not going to cause the kind of flooding that we saw in 1972 when the remnants of Tropical Storm Agnes moved over the northeastern part of the country because you don't have the big rivers and the big river valleys that would funnel that water. It would certainly cause a lot more water to be around, but I don't think that it would necessarily have provided that much greater risk to life in that particular community. The heavy rains that you get with a tropical storm or a hurricane can cause tremendous devastation if you have a lot of hilly terrain and a lot of mountain valleys to where you funnel that water.

Mr. **Andrews**. Well, what about the ability to evacuate the island and the areas on the mainland that are near——

Dr. **Frank**. If you get the rain before the arrival of the hurricane, it's certainly going to flood out some of those streets that we're planning to use for evacuation. You're absolutely right on that.

Mr. **Andrews**. In the gulf coast area, is vertical refuge—in your opinion, is that a viable alternative on places like Galveston Island? Is that a necessary step?

Dr. **Frank**. Oh, yes, I think it's very viable. You've got a fairly wide island where the city of Galveston is located. There are many of those buildings in the downtown Galveston area that went through the 1900 storm and did survive. The courthouse comes to my mind; that is a public-owned facility there. And you could go up into the hallway of the courthouse and survive even a storm like the 1900 one, in Galveston itself. And I think we could use some innovative planning and get private enterprise to solve a lot of our problems for us by making that one of the requirements for getting a permit—that you will allow people to come into that building. In addition to that, the building's going to be built a little bit stronger, going to make the hallways a little wider, we've got to have emergency toilet facilities planned in the building. And when the people come in, they wouldn't go into the expensive units, they'd go into the common-use areas and into the hallways and at least be able to survive.

Now, if we could solve the legal problems that surround this, I think we might be able to get on with it.

Mr. ANDREWS. When we've met before, we've talked about adequate warning systems for areas along the gulf coast and in the northeast as well. I wonder if you would comment or give your opinion on our rating system. Have you had opportunities to review it since your testimony before this subcommittee? Are you still confident in that system?

Dr. FRANK. OK. Now, Congressman, let me make sure I understand what you're asking me. You're talking about the scale that we use to rank hurricanes now?

Mr. ANDREWS. That's correct.

Dr. FRANK. OK. We have adopted a practice that has been used in the earthquake area into the hurricane area. You know, they have a Richter Scale to rank the past earthquakes on this Richter Scale, and we have a similar kind of scale that we've used in the hurricane area. It's called a Safford-Simpson Scale. Safford was a consulting engineer out at Coral Gables, and Simpson was my predecessor as Director of the National Hurricane Center. They developed a scale of one to five to rank hurricanes.

In the past, we haven't used that information in our advisory unless it was an intense hurricane. I don't want to go out with an advisory and say, "Well, folks, this is only a category 1; it's a weak one, don't worry about it." You know, hurricanes are still hurricanes, and so we probably wouldn't use that scale in our advice to the public unless it was a major hurricane. We might say, "Hey, folks, this is a category 4, becoming a category 5." We may have even used that in Alicia when we saw Alicia was strengthening and said, "Now, it's no longer a 1, it's become a 3." And we find there's pretty good response to it because it does help people put that storm into a little better perspective than just saying it's a hurricane.

Mr. ANDREWS. My concern is, like with Alicia, that it was ranked as a 1. I think a lot of people, knowing that a scale goes from 1 to 5, see a 1 as a mild storm; and then suddenly, within 45 minutes, Alicia went from a 1 to over a 3, I think, which is an extremely dangerous storm.

Dr. FRANK. Exactly.

Mr. ANDREWS. And I am concerned that the system might lull people because they're not knowledgeable about the way it works. Maybe over a period of time, through hearings like this and local attention to the rating system, people will have more confidence. But we know, in that storm, that a lot of people on Galveston Island, with that monster sitting out there, were being told that it was a 1 and did not really respond to local officials that were trying to warn them to be prepared, that this thing could hit Galveston Island and could go from a 1 very quickly to something very severe. A 1 is a severe storm, I think that's what you're saying; it's an intense hurricane——

Dr. **Frank**. Don't ignore it.

Mr. **Andrews** [continuing]. But I think a lot of people, with this system, might not see it that way, and that's a concern I have about it. Maybe time will take care of it.

Mr. Chairman, I have some other questions, but I at this time would pass the witness.

Mr. **Scheuer**. I'm going to ask unanimous consent that all members and staff will have permission to ask all of the witnesses questions in writing, and we'll hold the record open for 10 or 12 days or perhaps 2 weeks, if necessary, so that we could round out the record. We have seven witnesses this morning and they're all excellent witnesses. I didn't put this witness on the 5-minute rule because we did have the slide show, so I didn't put Members on the 5-minute rule, but we're simply not going to have time for all the questions from all of the members to all of the witnesses. So let's do as much in writing as we can.

I'm going to ask one question on behalf of the rest of us on this subject.

What is the difference in severity or danger between a class 1 and a class 3 hurricane?

Dr. **Frank**. A category 1 storm would be a minimal hurricane with winds in the range of maybe 75 to 95 miles an hour. Category 3 gets winds over 100 miles an hour, like—I don't remember the exact breakdown, but it's like 110 to 130 miles an hour. And when the winds go over 100 miles an hour, you might want to ask Professor Spangler here, I think you find that there's significant damage that begins to occur to buildings. That's why the category 3 was chosen as an arbitrary value for a major hurricane.

Mr. **Andrews**. Mr. Chairman, can I ask one more question, just to ask Dr. Frank to comment?

One issue that we have, and I apologize for this because it sounds so regional, is that we have some weather stations in our area, in Galveston; there have been proposals by this administration to close those weather stations. I wonder if you would care to testify as to what, in your opinion, is the need to have weather stations on the coast and close to susceptible areas like the gulf coast or on the Atlantic coastline?

Dr. **Frank**. Well, we work very closely with local government to develop the action plans that are required in local government. There are three groups of people that are involved in the hurricane warning team. There has to be one group of people that evaluates the meteorological elements; that's the Weather Service's responsibility. Then there has to be another group of people that determines what actions need to be taken in response to those weather elements, and that's local government. We work very closely with local government through our local Weather Service offices.

And then finally, the third group is the media, who have a very important role in communicating this information to the public. If they don't do their job properly, of course, the public just doesn't respond.

So we have worked very closely through our local Weather Service offices with local government to develop the plans that need to be implemented.

Mr. **Andrews**. Is it your opinion, professional opinion, that we need to keep those weather stations open in the Galveston area?

Dr. **Frank**. I certainly would say that in the past, this has been a very productive program, to have those local Weather Service stations active in the local planning.

Mr. **Andrews**. Thank you.

Thank you, Mr. Chairman.

Mr. **Scheuer**. Congressman Tom Lewis of Florida.

Mr. **Lewis**. Thank you, Mr. Chairman.

Dr. Frank, let me thank you for the excellent work you have done in this area, and I sort of sympathize with my colleague from Texas with the warning system problem that, having been a hurricane hunter 34 years ago, and a little bit less—I have watched the computers come into being and go from just the X-9 Radar to the sophisticated radars that we have today, and I sympathize with you. I don't know how you're going to be able to differentiate between a 1 and a class 3 or a class 5 storm any better than you're doing today. Storms can't count. We have Camille, which was a 100-year storm, but other storms can't count so we may have one this year or maybe 3 years from now. As an example, if that one had hit the southeast coast of Florida, particularly where I live, we would have been washed out completely.

I'm very much concerned as to what we can do to alert the public. The storm just—I forget the name of it; maybe it was Frank, I don't know—3 years ago, in which the center went over Singer Island, which is right close to my home, at 102 miles an hour. I was appalled at the precautions that were taken. I watched you on television pleading with the people to take the precautions and evacuate. The evacuation of south Florida today for a major storm would absolutely be a catastrophe, in my judgment, and I don't know how we can get the people to recognize this.

We have the problems, as you brought out, with the condominiums being built on the coastline. Certainly, none of those are vertical refuges that I see today, and I'm very much concerned that some way, as technology continues to progress in this area, that we get the people to apply the commonsense necessary—it doesn't take any technology, and I know you agree with this—because we were very lucky with Camille, I believe, at the time that that happened. But if we have anything to hit south Florida or even the Carolina coastline of a Camille origin or type, we are going to make the 6,000 deaths of the 1900 storm a real bush-league storm. And I'm concerned about that, and I want to applaud you for the work that you're doing. I'm interested in hearing the rest of the witnesses.

I have a number of questions, Mr. Chairman, but I will ask them in writing as well.

Thank you.

Mr. **Scheuer**. Congressman Tim Valentine of North Carolina.

Mr. **Valentine**. Thank you, Mr. Chairman.

Dr. Frank, I would like to ask you a question that might or might not fall within your jurisdiction. I was in my district a couple of days earlier this week, and I saw an item in one of the newspapers there indicating that there were some who felt that the cutbacks in personnel and/or in funds available to services similar to yours accounted for the fact that maybe some people didn't get proper and effective warnings in connection with those terrible natural disturbances which occurred in eastern South Carolina and North Carolina over the past several months.

My question to you is, are you able to say whether or not you believe that there have been any budget reductions affecting your operation that have caused you to not be able to do the job that you could do if you had more money? Now, I know that it's easy for people in Government to say—you know, when they start talking about reducing appropriations to this agency and that agency, it's very easy to say, "Well, if you do that, you know, we're going to cut out some needed services."

Can you comment on that long, complicated, and rambling question?

Dr. **Frank**. Well, let me address the answer specifically to my office. I have not been hurt with any kind of economic reductions over the last couple of years in terms of my staff. I'm a lot more concerned with my skills and abilities as a technical person than I am about the staff. We just don't know enough about the atmosphere to give the kinds of leadtime that is required now in many of these locations. I might just dispel a myth real quickly here; there's a myth going around that says because you've got satellites and you've got radar and you've got reconnaissance planes, you really must be doing a great job forecasting. Well, there's two things that you need to know about a storm if you're going to forecast where it's going. No. 1, you need to know about the storm. Well, we do a great job of observing it; no question about that. But then, if you're going to forecast where it's going, you've got to know what's going on in the environment around it. I need to know what's going on out over the Atlantic Ocean in the environment around the storm, and that's where I think we have a great lack. Economically, it's probably not feasible to go out into the middle of the Atlantic Ocean and locate 100 or 200 weather ships. So don't give me one, and expect a significant improvement; and I don't think there's enough money to put 200 out there. So, you know, we're faced with some dilemma in the fact that my skills, my technical skills in forecasting, are just not keeping pace with the tremendous pressure that is being brought on our office, and specifically the Weather Service, by the increasing population to provide the kind of leadtime that is required.

But certainly, in direct answer to your question, in my office I have not felt any pressure in that area.

Mr. **Valentine**. Thank you, sir.

Mr. **Scheuer**. Let me ask you some questions about cost effectiveness, the question of where society places its money. Do you spend *x* number of billions of dollars, or hundreds of millions, trying to develop a supersophisticated satellite prediction system that will give you 50 hours advance notice, instead of 12 to 24? Or do you spend billions of dollars building wider roads for all of our barrier islands? Or do you build or encourage developers to build a lot of high-rise apartments or high-rise structures—maybe they're schools or shopping centers or stores, or some kind of complex that once every 30 or 40 or 50 years could be used for that emergency?

The problem is complicated by the fact that it's a very infrequent need; and people tend to say, "Oh, the heck with it. I don't need to buy snow tires because it never really snows much in Washington." And then comes the occasional snow, like we had at President Kennedy's inauguration, and the town was chaosville.

So it's a question of priorities. Obviously—well, to me, if we could spend even in the hundreds of millions to develop a superduper sophisticated computer system that would enable you to identify where a hurricane was coming from and to track it and to give, say, 48 or 50 hours instead of your 12 to 24 hours, that advance notice would probably be the most cost effective if people would believe it and if they would act on it 2 days in advance, and not wait until 12 hours in advance so that you are in the same predicament that we are really in now.

I suppose you've taken yourself to the mountaintop and done some philosophizing.

Dr. **Frank**. Yes, sir.

Mr. **Scheuer**. Where should this Congress put its resources? Is it in a massive highway program to get people off the islands? Is it in high-rise construction? Or is it in better predictions so that, if we have another 24 hours or so, we can make do with the egress capability that we have now? Or is it in weather modification?

Dr. **Frank**. That's a very, very difficult question to answer, but let me just touch on two or three things.

No. 1, I think we can do some things that wouldn't be that expensive that would make sense. Why do we have to build the buildings right at the waterfront? Why don't we put them 100 yards back from the waterfront? We can still develop the barrier islands, still enjoy the great way of life that we have there; I've never advocated that we shouldn't develop the barrier islands, but I'm saying, why do we have to build the buildings right out on the waterfront? We have evidence that the wave action dissipates very fast. Now, you're still going to get the rising water back 100 yards, but you don't have the wave action with it. And if we would locate buildings back 100 yards or 200 yards from the waterfront, I think you would find that this would significantly reduce the damage that you would see. And it also might provide a place of safety for the people that would be trapped there. Amelia Island down at Jacksonville, just north of Jacksonville, is a good example of that kind of development. They put a golf course parallel to the beach, and the condominiums are on the inland side of the golf course; and so you've got the golf course as a buffer zone. Now, it's a beautiful development. It's attractive. So, you know, I think we could do some innovative things like that. I think we need to explore this concept of vertical evacuation and implement it before we have that great disaster.

I would also say to you that I would suggest that we need to get to our young people. We need to have some kind of an educational program throughout the grade school and high school systems so that when our young people come out of high school they're going to be sensitized to some of these kinds of issues. I've often said, "Let's develop a course on how to survive in modern society."

My specialty is hurricanes, but I'm also sympathetic to earthquakes and flash floods and all kinds of natural disasters; and with the mobility that we've got in our society, I think a youngster in Minnesota needs to know about earthquakes and also needs to know about hurricanes. But then you could have ecology, you could have energy, and all kinds of neat things in that, and maybe we can change the value systems of the young people so that in three or four decades, when they get in positions like you now have, that they would help make some of these decisions in our local communities that would be more sensitive to those kinds of issues.

Mr. **Scheuer**. Let's just make sure that's three or four decades away, minimum.

[General laughter.]

Dr. **Frank**. That perhaps isn't a very good answer, but I think there are some things we can do without building 15-foot seawalls along the entire Texas coast.

Mr. **Scheuer**. Yes.

Let me ask you about the Atlantic coast area, our area, Congressman McGrath and I. We've had very little—we've had no hurricane activity there in the last couple of decades. How has that affected us? Because there haven't been any episodes, have we been negligent? Have we been apathetic? Have we been unbelieving? Have we done things that have increased our risk? What is our posture now vis-a-vis that danger, let's say, as compared to the gulf coast area and the way they've conducted their developmental programs of all kinds over the last couple of decades? And is there a difference between the basic risk of the gulf coast area, and the basic risk of the Middle and North Atlantic coast area?

Dr. **Frank**. Two or three comments that I might make here.

No. 1, you're absolutely right; we haven't had bad hurricanes in the Northeast for two or three decades now. You can go back into the 1930's, 1938 and on into the 1940's and even into the early 1950's—we had a whole series of storms that moved up the east coast of the United States; Hurricane Carol in 1954 went over the eastern part of Long Island and on into the south shore of New England.

Now, there's a difference in the character of the land mass in the Northeast and in the gulf States in the sense that there is some high ground there. You know, you go to the Rhode Island coast and there's high ground right next to the waterfront, so you don't have to evacuate people from those particular areas. You don't have as many of the barrier islands except on the Jersey coast. The Jersey coast, of course, is a whole series of developed barrier islands, and we have great concern that we're not going to get those people out in the kind of leadtime that we could provide in our warnings.

So there is a difference in the character of the land so that the storm surge doesn't have, maybe, the same impact over on the south coast of New England as it would in Texas; but then you have, of course, the Jersey coast and other places where you do have similar kinds of barrier islands.

The second point I would make, in terms of the Northeast as compared to the gulf coast, is that hurricanes often pick up in their movement, their forward speed as they move into the Northeast. And that's what made the 1938 hurricane such a nightmare, because by the time it crossed the coast it was moving 50 or 60 miles an hour, where you've never seen that kind of motion in the gulf. So we're probably going to have more leadtime in the gulf to move people back than we're going to be able to provide some time when we have one of these fast-moving storms move up into the Northeast; and therefore, that makes the Northeast extremely vulnerable for these long leadtimes. We're just not going to be able to provide that kind of leadtime with the repeat of the 1938 storm. You might only get 6 hours of notice sometimes.

Mr. SCHEUER. Just one last question on this leadtime, this warning time which now is 6 or 12 hours, something like that, 15 hours.

Dr. FRANK. Congressman, I don't want to be misunderstood, because our goal in the past has been to try to provide 12 hours of leadtime for communities to respond in terms of their evacuation. We now know that isn't sufficient, so we're going to stretch our skills and try to provide longer leadtime; but we do that at a penalty, because now we have to warn a wider area so the overwarning becomes a problem, and maybe a breakdown of our credibility.

Mr. SCHEUER. The question of the boy who cried wolf, I suppose.

Dr. FRANK. That's right.

Mr. SCHEUER. What is it going to take to make that breakthrough? Is there a perfectly clear path of research and demonstration that it's going to take to improve the computer capability from 12 to 30 hours or the 50 hours I was talking about, or is there no clear technology in place now which—for which a predictable improvement could be achieved by diligent research? Is there going to have to be some kind of a quantum jump in technology to a new and heretofore-unexplored technology? Is it going to be extending the known, or is it going to be a great leap into the unknown that will give us that 2 days instead of a half a day?

Dr. FRANK. I'm not very optimistic that we're going to see that kind of a quantum jump in weather forecasting. Let's just take the United States; we're only sampling the atmosphere in the United States roughly every 100 miles. And out over the Atlantic Ocean, I do not have but one weather station—well, Bermuda.

Mr. SCHEUER. Well, this is just what I meant to ask. You see, if all we need to do is do a better job at what we now know, or know almost well enough—if it's a question of spending more money and doing a better job of data collection on the North American Continent, and perhaps over the ocean, and perhaps in the Arctic areas or wherever, but more or less with currently known technology, that's one thing. Then that's really the simplest challenge you're putting to us; is it worth a couple of hundred million dollars a year or whatever for us to have much better data collection, pushing the frontiers of that data collection out a bit, so that we can go from 12 to 30 hours?

Now, to go beyond *x* hours, are we going to need a whole new technology or whole new system, a whole new methodological approach? I'd like you to tell me—I mean, I think we'd all like you to tell us—just do what you're doing now, and help us do what we're doing now, only more of it and more precise and better and help us sharpen our sights and sharpen our pencils, and that's going to take money, but not a great deal that we don't know now. Is that more or less the case?

Dr. FRANK. Well, what I'm going to suggest to you is that we need to move forward on a number of fronts, and I certainly don't want to suggest here today that we shouldn't continue to do research in improving hurricane forecasting. But what I would try to stress to you is that there probably is not going to be a dynamic breakthrough, even if you put hundreds of millions of dollars into it. We're probably not going to see that dynamic breakthrough in the near future to solve this hurricane problem. The problem has become so great in terms of the amount of time it takes to get people back from the coastline—don't look to technology only, is what I'm suggesting, to solve the problem. We need to be looking at behavior aspects, and Dr. Baker is here and can comment on that; we need to look at some innovative things on evacuation. If we can't get everybody out horizontally, let's look for some other innovative things and solve the legal dilemmas that we need to solve. We need to move forward on an education program.

So I would suggest that we need to move forward on a lot of fronts, because I don't believe spending all the money just in the technology is going to solve the problem.

Mr. SCHEUER. This subcommittee has had several hearings in the past on the desirability of improving our global environmental forecasting system, our global weather forecasting system—not only for hurricanes, but for plant life, for deforestation, for desertification, for many phenomena, especially that take place in the Third World—flooding—that are of great concern to Third World planners. We've been able to give them a lot of help, and we've been talking about extending this global environmental monitoring system.

If we had better data collection, really on a global basis or weather and oceans and atmosphere, and if we could have a constant system of evaluation and analysis of that data that comes pouring in—computer analysis, I suppose it would have to be—from the point of view of hurricane formation, would that hold out hope for you, do you think?

Dr. FRANK. What I'm suggesting to you is that we'll see improvement. If we continue our program, continue to support those kinds of programs that you're talking about, yes, there is going to be improvement. But I don't think it's going to be the quantum leap that's going to solve the hurricane problem.

So what I'm suggesting is, yes, we do need to continue to work on the technology, but we need to look at some other problems because the technology probably isn't going to be the only—it won't solve the problem.

Mr. SCHEUER. Dr. Frank, I can't thank you enough for your testimony. As you know, we've gone way over on our time with you and it's because you've been so very interesting and stimulating. So thank you very, very much.

Mr. LEWIS. Mr. Chairman, before Dr. Frank leaves, may I ask him one question?

Mr. SCHEUER. By all means.

Mr. LEWIS. Dr. Frank, when are we going to have the next El Nino?

Dr. FRANK. El Nino? I trust that that's not going to be for several years now, because it does have quite an impact——

Mr. LEWIS. I just wanted to make a point, and you gave me a vague answer, because you can't tell me. And that's one of the problems we have with forecasting this storm.

As I mentioned earlier, 34 years ago I was flying in hurricanes. We have progressed like 2 years in tracking and forecasting since then, with all of the sophisticated things that we have.

Dr. **Frank**. Well, we're better than we were 30 years ago, but we're not good enough, fast enough.

Mr. Chairman, I do have a prepared statement that I would——

Mr. **Scheuer**. Well, that has been put into the record. We thank you for your testimony.

Dr. **Frank**. Thank you very much.

Mr. **Scheuer**. I apologize to my colleagues and I apologize to all the other witnesses for the fact that we're running very late. We're going to have to keep ourselves up here on a short leash, and we will be on the 5-minute rule now, and we will ask the future witnesses to contain themselves to 5 minutes.

Thank you very much, Dr. Frank.

We'll ask Dr. Samuel Speck, Associate Director of FEMA, the Federal Emergency Management Agency, to come forward.

We are delighted to have you, Dr. Speck. Your testimony will be printed in full in the record. If you could summarize your testimony in 5 or 6 minutes or 7 minutes, and then we'll have some time to ask you questions.

STATEMENT OF DR. SAMUEL W. SPECK, ASSOCIATE DIRECTOR, FEDERAL EMERGENCY MANAGEMENT AGENCY

Dr. **Speck**. Thank you, Mr. Chairman and members of the committee. I am Dr. Samuel Speck, Associate Director of FEMA for State and Local Programs and Support, and I appreciate the opportunity to come before you this morning.

As has already been indicated, hurricanes are one of the most threatening natural hazards facing the United States. It is estimated that some 40 million people live in the coastal communities from Texas to Maine, approximately 80 percent of whom have never experienced a hurricane and do not appreciate the threat that they are facing. Each year, thousands of people are moving into these hurricane-prone areas; indeed, there has been a 34-percent increase in the population of coastal counties in the last 2½ decades.

Without adequate emergency planning, warning, mitigation, and public awareness programs, the United States, as you well appreciate, could suffer a repeat of the 1900 Galveston hurricane which claimed some 6,000 lives. For this reason, FEMA has taken significant initiatives to help prepare for and cope with the potential of death and destruction and human suffering which hurricanes pose to many coastal areas.

FEMA, as you know, was created in 1979 to provide a single point of accountability for Federal emergency preparedness, mitigation, and response activities. The Agency is chartered to enhance the multiple use of emergency preparedness and response resources at all levels of Government in preparing for and responding to the full range of emergencies, natural and manmade. The Agency is further charged with integrating into a comprehensive framework, activities concerned with hazard mitigation, preparedness planning, response operations, and recovery assistance.

Just as the creation of FEMA took advantage of the inherent economies of bringing together emergency management organizations, FEMA is striving now to capitalize on the common elements within emergency functions—warning, communications, evacuation, sheltering, mass care, and the longer term functions of preparedness and mitigations for all hazards. To do this, FEMA in fiscal year 1984 has been field testing the integrated emergency management system, known as IEMS, with the full and automated implementation to take place in fiscal year 1985. Through the IEMS process, FEMA provides funding and technical assistance to States and local governments to enhance their overall emergency management capabilities. Because of the many common functions that must be performed in the event of an earthquake, hurricane, flood, chemical spill, or any other hazard, the IEMS concept substantially increases a community's ability to unite and reinforce planning and implementation aspects of the many hazard-specific programs.

I think this is an important thing for the committee to appreciate, because as you look at what FEMA is about, you need to look on one hand at, essentially, the civil defense program in which we now use the moneys as is provided for under the Civil Defense Act to allow us to assist communities and States in developing the capability to respond to all hazards. And then you need to look at the special hazard-specific monies and programs, and look at the combined effect of both of those to understand the total picture in terms of what we are trying to accomplish with State and local governments in preparedness for the broad range of hazards and the specific hazards in that process.

An example of IEMS is the Emergency Management Assistance Program. This program, funded in part by the civil defense budget, provides funds to establish and maintain an emergency management infrastructure at the State and local levels of government. It is this infrastructure, then, that supports preparedness, response, and recovery and, to a lesser degree, mitigation activities concerning all hazards, including earthquakes and hurricanes. We spend over $100 million in terms of grants to State and local governments to assist them in developing their overall ability to prepare for and respond to the broad range of hazards that they may confront.

In addition to the emergency management allocation, we provide allocations for State and local direction control and warning, which is critical in a hurricane threat. We provide, under our population protection, shelter surveys; and we are now going to all-hazard shelter surveys. In hurricane-prone areas, that means looking at shelters for their feasibility to be used as shelters in the event of a hurricane. This is a new program, a change in the sheltering program under population protection; it commenced this past year.

The IEMS process consists of four major steps: Hazard analysis and vulnerability assessment; capability assessment; operations planning; and, finally, multiyear development planning. Where are the communities today, and where do they need to go.

In terms of FEMA's specific hurricane preparedness programs, while IEMS provides a basis for generic emergency planning, it must be supplemented by hazard-specific activities. In fact, FEMA's role specifically relating to hurricanes is multifaceted and provides for a full range of pre- and post-hurricane activities. The preevent activities of the hurricane preparedness program and an active hurricane public awareness program, both of which I will speak to in a little bit more detail, coupled with the coastal building and construction provisions of the National Flood Insurance Program, provide the basis for planning, preparedness and mitigation. Correspondingly, postevent activities associated with federally subsidized flood insurance claims adjustment and with the implementation of the disaster assistance program provide programs for response and recovery. Disaster response and recovery is often FEMA's most visible role because the Agency coordinates all Federal recovery assistance and administers programs under the Disaster Relief Act of 1974, as amended.

Mr. SCHEUER. Dr. Speck——

Dr. SPECK. Yes?

Mr. SCHEUER [continuing]. Your time has expired. I really regret having to call time limits, but I'm going to do that on myself and my colleagues, too. If you can really sum up in the next minute and give us time to ask you questions, we would appreciate it.

Dr. SPECK. I apologize, Mr. Chairman. The information that I was given was that I would have 10 minutes, and I made my remarks according to the initial information I was given; apparently that was not correct.

Let me try to be responsive to your time constraints, although you aren't going to get as good an overall picture.

What is FEMA involved in terms of the specific hurricane programs as contrasted with our overall general preparedness programs that are also very important to hurricane preparedness planning?

First of all, we're involved in building on the SLOSH model and the simulations that come out of that in assisting communities to develop preparedness plans. We have, for example a prototype that was done for the Tampa Bay area with FEMA funding. We assist—here's one, Preparing for Hurricanes and Coastal Flooding: A Handbook for Local Officials.

In addition to providing funding for State and local governments to develop hurricane preparedness programs, we also are involved in a great deal of work with NOAA in league with the State and local governments in terms of awareness. The critical factor of making people aware of what the threat is when they go to decide where they're going to be constructing their facilities, and also in respect to evacuation.

Mr. Chairman, I brought you a large packet of the kinds of materials that FEMA has provided funding for development and for distribution. We are working with State and local governments to provide for specific kinds of hurricane awareness information. Here's a guide for the elderly; action guides for schoolchildren; for hotel and motel operators; for marina and boat operators; for State and local governments, and the like.

We have also been involved in funding specific area response plans, and I have brought some of those to share with the committee, as well.

We have done a whole series of things, working with State and local governments, in the area of hurricane preparedness. In the area of mitigation, we have been involved, of course, in our flood plain zoning program, in the National Flood Insurance Program, in encouraging people, first of all not to build in floodprone areas in the first place; and, second, when there is a flood, requiring local governments to be involved in mitigation programs so that we don't have a recurrence of the same kind of thing.

We also have a modest—what is called the 1362 Program, in which there are areas that are continually floodprone and we've done some of this in Galveston. As part of the settlement, we will apply the settlement moneys to relocating the people in other areas.

One of the things that you have before Congress at the present time are some proposals for amending the Disaster Relief Act of 1974. One of those very important amendments is an amendment that would allow us to contribute matching funds for mitigation to avoid disasters, mitigation where disasters have taken place, so they will not reoccur.

And finally, of course, in our disaster assistance programs we assist State and local governments and individuals in the recovery from disaster.

Mr. Chairman, you will be given copies of our latest FEMA Newsletter which, in this particular July-August edition, headlines the Georgia hurricane preparedness program in which we have been involved. I also have a chart here for the record indicating the level of funding and the substantial increase in funding devoted specifically to hurricane preparedness over the last 5 years, and a chart for you showing precisely where that is going in each of the 22 areas in which we have SLOSH models—20 of which have been developed, and two more of which are in the stage of development and will be completed by the end of this next fiscal year.

[The prepared statement plus the FEMA Newsletter and the charts mentioned above of Dr. Speck follow:]

TESTIMONY
OF
SAMUEL W. SPECK
ASSOCIATE DIRECTOR
STATE AND LOCAL PROGRAMS
AND SUPPORT
FEDERAL EMERGENCY MANAGEMENT AGENCY

SUBMITTED TO U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

AUGUST 9, 1984

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE, THANK YOU FOR INVITING ME TO TESTIFY TODAY ON BEHALF OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA).

HURRICANES ARE ONE OF THE MOST THREATENING NATURAL HAZARDS FACING THE UNITED STATES. IT IS ESTIMATED THAT APPROXIMATELY 40 MILLION PEOPLE LIVE IN COASTAL COMMUNITIES FROM TEXAS TO MAINE, APPROXIMATELY 80% OF WHICH HAVE NEVER EXPERIENCED A HURRICANE. EACH YEAR THOUSANDS OF PEOPLE CONTINUE TO MOVE INTO HURRICANE PRONE AREAS. WITHOUT ADEQUATE EMERGENCY PLANNING, WARNING, MITIGATION, AND PUBLIC AWARENESS PROGRAMS, THE NATION COULD FACE A REPEAT OF THE 1900 GALVESTON HURRICANE THAT CLAIMED SIX THOUSAND LIVES. FOR THIS REASON, FEMA PLAYS A VERY IMPORTANT ROLE IN HELPING PREPARE FOR AND COPE WITH THE POTENTIAL DEATH, DESTRUCTION, AND HUMAN SUFFERING WHICH HURRICANES POSE TO THE COASTAL AREAS OF THE NATION.

BACKGROUND

FEMA WAS CREATED IN 1979 TO PROVIDE A SINGLE POINT OF ACCOUNTABILITY FOR ALL FEDERAL EMERGENCY PREPAREDNESS, MITIGATION, AND RESPONSE ACTIVITIES. THE AGENCY IS CHARTERED TO ENHANCE THE MULTIPLE USE OF EMERGENCY PREPAREDNESS AND RESPONSE RESOURCES AT THE FEDERAL, STATE, AND LOCAL LEVELS IN PREPARING FOR AND RESPONDING TO THE FULL RANGE OF EMERGENCIES - NATURAL, AND MANMADE. FEMA IS FURTHER CHARGED WITH INTEGRATING INTO A COMPREHENSIVE FRAMEWORK, ACTIVITIES CONCERNED WITH HAZARD MITIGATION, PREPAREDNESS PLANNING, RESPONSE OPERATIONS AND RECOVERY ASSISTANCE.

JUST AS THE CREATION OF FEMA TOOK ADVANTAGE OF THE INHERENT ECONOMIES OF BRINGING TOGETHER EMERGENCY MANAGEMENT ORGANIZATIONS, FEMA IS STRIVING TO CAPITALIZE ON THE COMMON ELEMENTS WITHIN EMERGENCY FUNCTIONS (WARNING, COMMUNICATIONS, EVACUATION, SHELTERING, MASS CARE, ETC.) AND THE LONGER-TERM FUNCTIONS OF PREPAREDNESS AND MITIGATION FOR ALL HAZARDS. TO DO THIS FEMA IN FY 1984 FIELD TESTED THE INTEGRATED EMERGENCY MANAGEMENT SYSTEM (IEMS) WITH FULL AND AUTOMATED IMPLEMENTATION TO TAKE PLACE IN FY 1985. THROUGH THE IEMS PROCESS, FEMA PROVIDES FUNDING AND TECHNICAL ASSISTANCE TO STATES AND LOCAL GOVERNMENTS TO ENHANCE THEIR OVERALL EMERGENCY MANAGEMENT CAPABILITY. BECAUSE OF THE MANY COMMON FUNCTIONS THAT MUST BE PERFORMED IN THE EVENT OF AN EARTHQUAKE, HURRICANE, FLOOD, CHEMICAL SPILL, OR ANY OTHER HAZARD, THE IEMS CONCEPT SUBSTANTIALLY INCREASES A COMMUNITY'S ABILITY TO UNITE AND REINFORCE PLANNING AND IMPLEMENTATION ASPECTS OF THE MANY HAZARD--SPECIFIC PROGRAMS.

AN EXAMPLE OF IEMS IS THE EMERGENCY MANAGEMENT ASSISTANCE PROGRAM. THIS PROGRAM, FUNDED AS PART OF THE CIVIL DEFENSE

BUDGET, PROVIDES FUNDS TO ESTABLISH AND MAINTAIN AN EMERGENCY MANAGEMENT INFRASTRUCTURE AT THE STATE AND LOCAL LEVELS OF GOVERNMENT. IT IS THIS INFRASTRUCTURE THAT SUPPORTS PREPAREDNESS, RESPONSE, AND RECOVERY AND TO A LESSER DEGREE, MITIGATION ACTIVITIES CONCERNING ALL HAZARDS--INCLUDING EARTHQUAKES, HURRICANES, AND SO FORTH.

THE IEMS PROCESS CONSISTS OF 4 MAJOR STEPS: (1) HAZARD ANALYSIS AND VULNERABILITY ASSESSMENT; (2) CAPABILITY ASSESSMENT; (3) OPERATIONS PLANNING; AND (4) A MULTI-YEAR DEVELOPMENT PROGRAM. THIS IEMS PROCESS WILL ALLOW STATE AND LOCAL PARTICIPATION IN FEMA'S BUDGETARY PROCESS.

FEMA'S ROLE RELATING TO HURRICANES

WHILE IEMS PROVIDES A BASIS FOR GENERIC EMERGENCY PLANNING, IT MUST BE SUPPLEMENTED BY HAZARD SPECIFIC ACTIVITIES. IN FACT, FEMA'S ROLE SPECIFICALLY RELATING TO HURRICANES IS MULTI-FACETED AND PROVIDES FOR A FULL RANGE OF PRE AND POST HURRICANE ACTIVITIES. THE PRE-EVENT ACTIVITIES OF THE HURRICANE PREPAREDNESS PROGRAM AND AN ACTIVE HURRICANE PUBLIC AWARENESS EFFORT (BOTH OF WHICH I WILL DISCUSS MORE FULLY) COUPLED WITH THE COASTAL BUILDING AND CONSTRUCTION PROVISIONS OF THE NATIONAL FLOOD INSURANCE PROGRAM PROVIDE A BASIS FOR PLANNING, PREPAREDNESS AND MITIGATION. CORRESPONDINGLY, POST-EVENT

ACTIVITIES ASSOCIATED WITH FEDERALLY SUBSIDIZED FLOOD INSURANCE CLAIMS ADJUSTMENT AND WITH THE IMPLEMENTATION OF DISASTER ASSISTANCE PROVIDE PROGRAMS FOR RESPONSE AND RECOVERY. DISASTER RESPONSE AND RECOVERY IS OFTEN FEMA'S MOST VISIBLE ROLE BECAUSE THE AGENCY COORDINATES ALL FEDERAL RECOVERY ASSISTANCE AND ADMINISTERS PROGRAMS UNDER THE DISASTER RELIEF ACT (PL 93-288 AS AMENDED).

THE IMMEDIATE POST-DISASTER SITUATION, SUCH AS WOULD OCCUR FOLLOWING A DEVASTATING HURRICANE, OFTEN PRESENTS MANY OPPORTUNITIES TO ALLEVIATE FUTURE RISKS. CURRENTLY, THE DISASTER RELIEF ACT DIRECTS THAT STATES INCLUDE HAZARD MITIGATION PROGRAMS AND AN EVALUATION OF NATURAL HAZARDS IN THEIR DISASTER PLANS. IT ALSO PRECLUDES FEDERAL ASSISTANCE FOR REPAIR OR REPLACEMENT OF PUBLIC FACILITIES UNLESS THE AFFECTED GOVERNMENTAL JURISDICTION AGREES TO REPLACEMENT IN COMPLIANCE WITH ENVIRONMENTAL PROTECTION, FLOOD PLAIN MANAGEMENT AND HAZARD MITIGATION CRITERIA. HOWEVER, TO TAKE FULL ADVANTAGE OF THE POST DISASTER SITUATION THE ADMINISTRATION HAS SUBMITTED TO CONGRESS AMENDMENTS TO THIS ACT WHICH WOULD ALLOW FEMA, FOR THE FIRST TIME, TO CONTRIBUTE A PERCENTAGE OF THE COST OF MITIGATION MEASURES WITH THE BALANCE TO BE CONTRIBUTED BY THE APPROPRIATE STATE OR LOCAL JURISDICTION. ADDITIONAL AMENDMENTS ALLOW FEDERAL AGENCIES-ACTING WITH STATE AND LOCAL GOVERNMENTS-TO INITATE MEASURES TO MINIMIZE THE POTENTIAL FOR REOCURRENCE OF DAMAGES RESULTING FROM DISASTERS.

FEMA ALSO PLAYS AN INTEGRAL COORDINATING ROLE WITH RESPECT TO HURRICANE PLANNING EFFORTS. FEMA CONVENED AN INTERAGENCY HURRICANE WORK GROUP COMPRISED OF THOSE FEDERAL AND VOLUNTARY RELIEF AGENCIES ACTIVELY INVOLVED IN HURRICANES ACTIVITIES. THESE WERE THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA), THE NATIONAL WEATHER SERVICE (NWS), THE U.S. ARMY CORPS OF ENGINEERS (COE), AND THE AMERICAN RED CROSS (ARC). THAT GROUP, WHICH MET INITIALLY IN JUNE 1982, NOW MEETS ON A QUARTERLY BASIS. THE ESTABLISHMENT OF THIS GROUP TO DISCUSS MUTUAL CONCERNS, EFFORTS AND PROGRAMS IN AN OPEN FORUM HAS ENABLED THE COLLECTIVE AGENCIES TO ADDRESS SUCH DIVERSE, BUT IMPORTANT SUBJECTS, AS VERTICAL EVACUATION, STORM PROBABILITIES, AND FUTURE PROGRAM DIRECTION. FROM THESE DISCUSSIONS A CONSENSUS APPROACH IN DEALING WITH HURRICANE RISK ISSUES HAS BEEN ACHIEVED.

FOR EXAMPLE, IN FEBRUARY, 1983 THE ABOVE AGENCIES AND SELECTED STATES MET IN ATLANTA TO DISCUSS HURRICANE WARNING AND PREPAREDNESS PLANNING. IT WAS THE CONSENSUS OF THE PARTICIPANTS THAT THE NWS SLOSH (SEA, LAKE, OCEAN, SURGE FROM HURRICANES) COMPUTER MODEL IS AN ESSENTIAL ELEMENT OF HURRICANE PREPAREDNESS PLANNING ACTIVITIES. FEMA STRONGLY ENDORSES IT'S USE AND HAS INCORPORATED IT INTO OUR PLANNING ACTIVITIES.

FEMA'S HURRICANE PREPAREDNESS PROGRAM

THE HURRICANE PREPAREDNESS PROGRAM PROVIDES TECHNICAL AND

FINANCIAL ASSISTANCE TO STATES IN DEVELOPING NEW OR MODIFIED PREPAREDNESS PLANS TO COPE WITH A HURRICANE DISASTER IN HIGH-RISK, HIGH-POPULATION AREAS. THE PROGRAM ENHANCES THE IEMS GOALS OF POPULATION AND PROPERTY PROTECTION BY DEVELOPING THE NECESSARY HAZARD SPECIFIC DATA ANALYSIS AND ADDRESSING CHARACTERISTIC PROBLEMS OF HURRICANE DISASTERS FOR THE COMMON FUNCTIONS OF RESPONSE, RECOVERY, AND MITIGATION.

INITIALLY 19 HIGH-RISK, HIGH-POPULATION AREAS ALONG THE ATLANTIC AND GULF COASTS AND THE PACIFIC AND CARRIBEAN AREAS WERE IDENTIFIED BY FEMA. IN CONSULTATION WITH NWS, THE NUMBER OF HIGH-RISK, HIGH-POPULATION AREAS WAS LATER REFINED TO 22 BY REDESIGNATION AND IDENTIFICATION OF NEW AT RISK AREAS. FEMA SUPPORT FOR PLANNING AND PREPAREDNESS IS COMPLETED OR ON GOING IN 15 OF THESE AREAS; AND $2.3 MILLION FROM FEMA HAS BEEN FUNDED SINCE THE PROGRAM BEGAN IN 1981. THIS MODESTLY PRICED PROGRAM, AT THE CURRENT LEVEL OF FUNDING IS ESTIMATED TO TOTAL $6.0 MILLION FOR ALL OF THE 22 AT RISK AREAS.

FEMA'S HURRICANE PREPAREDNESS PROGRAM CONSISTS OF TWO PHASES. POPULATION PROTECTION PLANNING IS THE PRIMARY GOAL OF HURRICANE PREPAREDNESS. A PLAN DIRECTED TOWARD THIS GOAL MUST BE DEVELOPED FIRST, OR COMPLETED BEFORE, AN APPLICATION FOR DEVELOPMENT OF A PROPERTY PROTECTION PLAN WILL BE CONSIDERED ELIGIBLE FOR FEMA

FUNDING. REDUCING LOSS OF LIFE AND INJURIES IN A HURRICANE DISASTER IS THE PRIMARY OBJECTIVE THAT MUST BE ACHIEVED.

AN ACCEPTABLE POPULATION PROTECTION PLAN INCLUDES, AT A MINIMUM, (1) A TECHNICAL DATA REPORT, (2) AN EVACUATION PLAN, (3) A PUBLIC INFORMATION PROGRAM, AND (4) AN EXERCISE OF THE EVACUATION PLAN. THE TECHNICAL DATA REPORT IS A DETAILED REPORT PRESENTING THE RESULTS OF INVESTIGATIONS, STUDIES AND ANALYSES OF WHAT IS NEEDED TO DEVELOP AND IMPLEMENT A SAFE HURRICANE EVACUATION PLAN. INCLUDED IN THE REPORT WILL BE A HAZARD ANALYSIS BASED ON A HURRICANE SURGE MODEL, A VULNERABILITY ANALYSIS OF THE AREAS AT RISK TO STORM SURGE FLOODING, A BEHAVIORAL ANALYSIS OF POPULATION RESPONSE TO EVACUATION ORDERS, A SHELTER ANALYSIS, AND A TRANSPORTATION ANALYSIS. CONSISTENT WITH THE RECOMMENDATIONS OF THE INTERAGENCY HURRICANE GROUP, WHEREVER POSSIBLE THE SEA, LAKE, OVERLAND SURGE FROM HURRICANE (SLOSH) MODEL IS APPLIED TO THE AT RISK AREA BEING STUDIED.

SINCE EVACUATION IS THE PRIMARY RESPONSE EFFORT FOR A HURRICANE EMERGENCY, THE EVACUATION PLAN TIES TOGETHER THE VARIOUS TECHNICAL DATA REPORTS WITH THE DETAILED IMPLEMENTATION PROCEDURES FOR EVACUATION. EMERGENCY WARNING, COORDINATION, AND OPERATING PROCEDURES ARE DETAILED IN THE EVACUATION PLAN. ALSO, INCLUDED ARE THE AREAS AND NUMBER OF PEOPLE TO BE EVACUATED, ESCAPE ROUTES, EVACUATION TIME ESTIMATES, AND SHELTER ASSIGNMENTS

FOR THE DIFFERENT HURRICANE SCENARIOS. A PUBLIC INFORMATION PROGRAM AND SCHEDULE FOR EXERCISE COMPLETES THE POPULATION PROTECTION PLAN. LOCAL PUBLIC INFORMATION PROGRAMS AND EXERCIZING OF THESE PLANS BY LOCAL OFFICIALS ARE INTEGRAL TO EFFECTIVE IMPLEMENTATION WHEN A HURRICANE STRIKES.

FOR THE GOAL OF PROPERTY PROTECTION, THE OBJECTIVE IS TO REDUCE PROPERTY DAMAGES. USING INUNDATION AREA MAPS BASED ON SLOSH , AN INVENTORY OF STRUCTURES, LIFELINES AND HAZARDOUS MATERIALS STORAGE AREAS IS MADE ALONG WITH AN ESTIMATE OF DAMAGES AND IMPACTS. A SOCIO-ECONOMIC IMPACT ANALYSIS IS ALSO PREPARED TO DELINEATE PUBLIC SERVICE AND SOCIAL DISRUPTION. THESE TECHNICAL DATA STUDIES COMPLETE THE VULNERABILITY ANALYSIS PORTION OF THE PREPAREDNESS PLANNING PROCESS AND ARE THE BASIS FOR THE HURRICANE RECOVERY AND MITIGATION PLANNING ACTIVITIES.

HURRICANE RECOVERY PLANS PROVIDE STRATEGIES FOR THE FOLLOWING PERIODS: (1) IMMEDIATE EMERGENCY, (2) SHORT-RANGE RESTORATION AND (3) LONG-TERM RECONSTRUCTION. THE IMMEDIATE EMERGENCY PERIOD ACTIVITIES ARE COORDINATED BY THE OPERATIONS PERSONNEL IN THE LOCAL GOVERNMENT EMERGENCY OPERATIONS CENTERS. OBJECTIVES OF THE IMMEDIATE EMERGENCY PERIOD ARE TO PROVIDE FOR SEARCH AND RESCUE, RETURN OF EVACUEES, EMERGENCY MEDICAL AID, SUSTENANCE SUPPLIES, AND INITIAL ASSESSMENT OF DAMAGES. IN THE SHORT-RANGE RESTORATION PERIOD, OBJECTIVES ARE TO MEET SPECIFIC NEEDS AND ARE

LIMITED TO THOSE ACTIONS WHICH ARE NECESSARY TO SAVE LIVES, PROTECT PROPERTY, MAINTAIN PUBLIC HEALTH AND SAFETY, AND LESSEN THE THREAT OF A MORE SEVERE DISASTER. THE DECISION TO OBTAIN A PRESIDENTIAL DISASTER DECLARATION AND TO REQUEST FEDERAL RESOURCES AS WELL AS STATE RESOURCES IS REVIEWED IN THIS PERIOD. IN THE LONG-TERM RECONSTRUCTION PERIOD, OBJECTIVES ARE TO RETURN LIFE AND THE COMMUNITY BACK TO NORMAL OPERATIONS. ACTIVITIES TO ACCOMPLISH THESE OBJECTIVES ARE PERFORMED AND THE NECESSARY REPAIRS MADE. IMPLEMENTATION OF MITIGATION PLANS AND STRATEGIES TO LESSEN THE SEVERITY OF A FUTURE HURRICANE DISASTER IS INITIATED DURING THIS PERIOD.

A MITIGATION PLAN HAS AS ITS OBJECTIVE THE LESSENING OR REDUCTION OF IMPACTS OF A FUTURE HURRICANE DISASTER THROUGH A REDUCTION OF DAMAGES. BOTH SHORT-TERM AND LONG-TERM AS WELL AS PRE-EVENT AND POST-EVENT STRATEGIES MUST BE PART OF THE MITIGATION PLAN. MITIGATION STRATEGIES TO ACCOMPLISH THESE OBJECTIVES INCLUDE PREVENTION OF DEVELOPMENT IN VULNERABLE AREAS, ESTABLISHMENT OF HURRICANE-RESISTANT BUILDING PRACTICES, AND RETURN OF VULNERABLE AREAS TO OPEN SPACE USES AFTER THE DAMAGED STRUCTURES ARE REMOVED. A MAJOR MITIGATION ACTION WHICH CAN BE CARRIED OUT BY ALL FLOOD-PRONE COMMUNITIES IS IMPLEMENTING THE REQUIREMENTS OF THE NATIONAL FLOOD INSURANCE PROGRAM AND PURCHASING FLOOD INSURANCE FOR VULNERABLE STRUCTURES.

PUBLIC AWARENESS

NO MATTER HOW THOROUGH THE PLANS, IF CITIZENS DO NOT ACT, MUCH IS LOST. OUR PUBLIC AWARENESS ACTIVITIES ARE A VITAL LINK IN RAISING THE LEVEL OF CITIZEN PREPAREDNESS TO DEAL WITH HURRICANES. FEMA HAS JOINED WITH NOAA TO DEVELOP MANY AWARENESS ACTIVITIES ONE OF WHICH WAS TO SPONSOR AN ANNUAL HURRICANE AWARENESS CAMPAIGN. THE CAMPAIGN GOAL HAS BEEN TO IDENTIFY, DEVELOP, DISTRIBUTE AND PROMOTE HURRICANE PREPAREDNESS INFORMATION USING A COST-EFFECTIVE, SELF HELP APPROACH WITHIN THE COMMUNITY. THE CAMPAIGN KIT HAS BEEN DESIGNED TO STIMULATE STATE AND LOCAL GOVERNMENTS, BUSINESS, AND TRADE GROUPS TO DEVELOP AWARENESS PROGRAMS AND TO ENCOURAGE USE OF SUCCESSFUL TECHNIQUES ADOPTED BY OTHER COMMUNITIES.

ALL EFFORTS HAVE BEEN COOPERATIVE WITH NOAA, AND IN THE PAST YEAR, WE HAVE INCLUDED THE AMERICAN RED CROSS IN THE PLANNING EFFORTS -- FROM SHARING PRODUCTION COSTS, TO THE TIMING AND FOCUS OF OUR MESSAGES, TO PRESENTATIONS AT NATIONAL MEETINGS AND IN FRONT OF MEDIA GATHERINGS. THIS ALLOWS THREE NATIONAL AGENCIES TO FOCUS PUBLIC ATTENTION ON THE SAME MESSAGE AT THE SAME TIME.

APPROXIMATELY 200 MAJOR TRADE GROUPS AND CORPORATIONS HAVE PARTICIPATED IN THE CAMPAIGN NATIONALLY. FOR EXAMPLE, THE WEATHER CHANNEL, THE 24 HOUR CABLE WEATHER STATION BASED IN

ATLANTA, HAS WORKED COOPERATIVELY WITH US TO DEVELOP T.V. SPOTS AND TO PROMOTE THE CAMPAIGN MATERIALS TO THE PUBLIC. IN THE FIRST YEAR, A SAMPLE OF PARTICIPANTS SHOWED 45% OF THE KIT REQUESTS WERE FROM PRIVATE CORPORATIONS OR INSURANCE COMPANIES, 37% FROM STATE AND LOCAL ORGANIZATIONS, AND 10% FROM THE MEDIA.

IN THE LAST TWO YEARS, THE DEVELOPMENT OF AWARENESS MATERIALS HAS RECEIVED CONSIDERABLE ATTENTION. THE 310 NATIONAL WEATHER SERVICE FIELD OFFICES AND THE AMERICAN RED CROSS CHAPTERS PLAY A MAJOR ROLE IN GETTING INFORMATION TO THE PUBLIC. FEMA IS ALSO FOCUSING ON GETTING INFORMATION TO THE EMERGENCY MANAGEMENT PROFESSIONALS ABOUT SUCCESSFUL TECHNIQUES THAT HAVE WORKED.

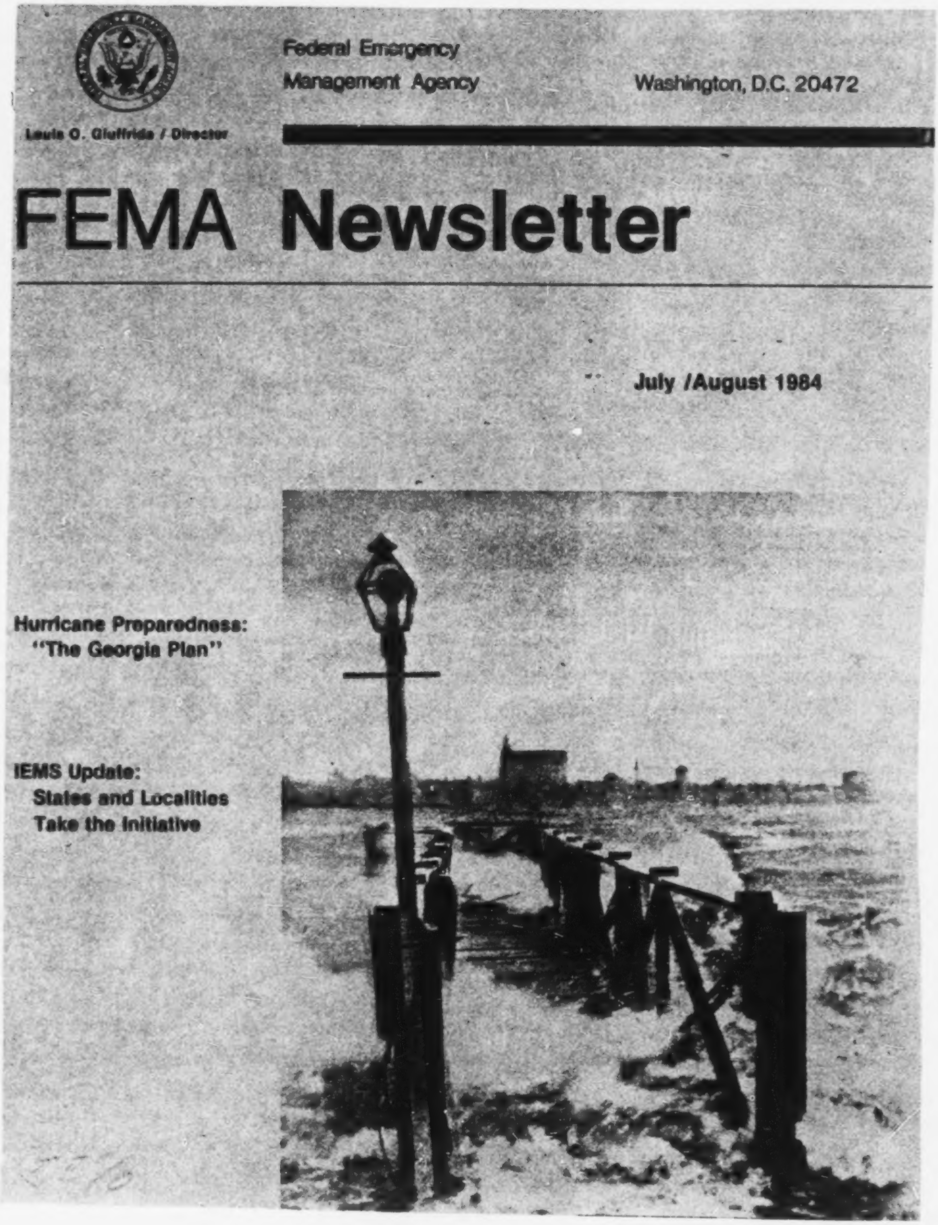
THIS MONTH FEMA IS PUBLISHING A MONOGRAPH ON THIS SUBJECT. ALSO, FEMA'S NEWSLETTER WHICH GOES TO 20,000 PROFESSIONALS, HIGHLIGHTS THE SUCCESSFUL HURRICANE PREPAREDNESS PROJECT UNDERTAKEN BY THE GEORGIA COASTAL AREA PLANNING AND DEVELOPMENT COMMISSION.

FEMA WILL CONTINUE TO FUND AND COMPLETE THE HURRICANE PREPAREDNESS PROGRAMS FOR THE REMAINING SEVEN HIGH RISK AREAS. HOWEVER, FEMA RECOGNIZES THAT THE SELECTION OF THOSE HIGH-RISK/ HIGH-POPULATION AREAS IS DYNAMIC. PRIORITIES AND SCHEDULING HAVE BEEN AND WILL CONTINUE TO BE CLOSELY COORDINATED WITH NOAA/NWS. AS FEMA'S EFFORTS PROGRESS OVER THE NEXT SEVERAL YEARS, THE PLANNING PROCESSES TO BE INITIATED IN THOSE AT-RISK AREAS WILL BE TIED INTO THE COMPLETION OF THE SLOSH PROGRAM.

ADDITIONAL INITIATIVES CURRENTLY PLANNED INCLUDE:

- CONTINUING THE COOPERATIVE AWARENESS PROGRAM WITH NOAA;
- DEVELOPING A PROGRAM TO EVALUATE THE EFFECTIVENESS OF FEMA'S HURRICANE PREPAREDNESS PROGRAM FOLLOWING A HURRICANE EVENT;
- ADOPTING A COMPUTER MODEL USED BY FEMA'S REP PROGRAM FOR EVACUATION PLANNING AROUND NUCLEAR POWER PLANTS TO ASSIST IN SIMULATING HURRICANE EVACUATION PLANNING, AND
- INITIATING A REVIEW OF THE FEDERAL APPROACH TO TORNADO PREPAREDNESS TO ASCERTAIN IF STATE AND LOCAL NEEDS ARE BEING MET.

THIS CONCLUDES MY FORMAL STATEMENT. THANK YOU FOR THE OPPORTUNITY TO SHARE WITH YOU INFORMATION ON FEMA AND OUR HURRICANE PREPAREDNESS PROGRAM. I WOULD NOW BE HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE ON THESE MATTERS.



Federal Emergency
Management Agency

Washington, D.C. 20472

Louis O. Giuffrida / Director

FEMA Newsletter

July /August 1984

Hurricane Preparedness:
"The Georgia Plan"

IEMS Update:
States and Localities
Take the Initiative

2

Hurricane Preparedness: "The Georgia Plan"

by: Thomas R. De Kay, Ph.D.

Nearly 350,000 people reside on or near the 112-mile stretch of Georgia coastline—a coastline affected by one out of every seven hurricanes in the Atlantic region. In 1980, Georgia's Coastal Area Planning and Development Commission (CAPDC) began studying the needs of local governments in disaster preparedness planning. The study resulted in a model storm preparedness program that is both comprehensive and innovative.

What began with a Cooperative Agreement with FEMA for the implementation of a prototype storm program was continued through successful local initiatives. Federal funding totaled $133,000 and was awarded to the CAPDC in 1981-82. Money to continue the project was obtained through a voluntary tax of 50¢ per capita in the 29 coastal and host counties involved.

The key to the success of "The Georgia Plan" is found in this introductory statement to the Storm Preparedness Guide, developed by the CAPDC and published last April: "A storm preparedness program is more than just a set of documents containing response procedures. It is an ongoing, coordinated effort to prepare the general public for emergency situations. It is also an effort to prepare responsible public and private agencies and groups that direct, control, and support operations in emergency situations. In short, it is the difference between having a written plan and active planning."

Fully implemented in the coastal Georgia area by 1983, the program incorporates several critical elements: the **intergovernmental coordination** process guided development of the overall program followed by the development of major functional areas including **planning, public education**, and **mapping**.

HOST COUNTY HURRICANE RESPONSE PLAN
LONG COUNTY HURRICANE RESPONSE PLAN
STORM PREPAREDNESS PLANNING GUIDE
HURRICANE AWARENESS
ACTION GUIDELINES FOR THE ELDERLY
ACTION GUIDELINES FOR LOCAL GOVERNMENT EMPLOYEES/OFFICIALS
ACTION GUIDELINES FOR HOTEL/MOTEL OPERATORS

Intergovernmental Coordination

At the outset of the program, the CAPDC formed an Advisory Council on Storm Preparedness. The Council consists of approximately 65 representatives of federal, state, and local governments, volunteer groups, and other emergency management partners. Meeting on a regular basis, the Council and its committees provide ongoing guidance to the project and serve as a forum for discussion of disaster preparedness issues, response problems, and realistic solutions. Several subcommittees concentrate on education; communication and warning; resources and coordination; emergency services; evacuation, transportation, and re-entry; shelters; cleanup and recovery; and host county planning.

Planning

A unique element of the plan is the designation and participation of inland or "host" counties. In addition to the six coastal counties designated as evacuation areas, 23 host counties participated in planning and preparedness efforts. Uniform plans were developed for reception and care of evacuees in host areas, with routes mapped, shelters identified, and emergency personnel designated for both response and recovery phases.

Evacuation planning began with a telephone survey of households in the designated evacuation areas. Survey results indicated that the least likely residents to evacuate were those with the longest period of residency. Obviously, an effective public information/education program was needed, as well as a reliable network to inform residents of the dangers of "riding out" a storm.

Public Education

Public education efforts began with the identification of target audiences—local government employees/officials; the elderly; school children; hotel/motel operators; and marina/boat operators. Then a series of formal action guidelines were prepared and distributed. Each guideline provides preparedness and safety information designed for a specific target group. An ongoing educational program, including seminars and other "hands-on" public contacts, was initiated and made an important part of the public information program.

CAPDC staff also worked with the local news media to ensure a uniform program of communication and warning for the general public. In cooperation with the National Weather Service (NWS), a five-phase storm condition/preparedness/response activity was put into operation. Beginning with "Condition 5," which identifies the development of a tropical storm disturbance, the public is made aware of the various stages of hurricane development. At "Condition 1" (a declaration that a hurricane will probably strike an area of the Georgia coast within 12 hours) a full-fledged emergency is declared and hurricane response plans are implemented.

Mapping

Perhaps the most time-consuming aspect of developing the storm preparedness program was the mapping procedure. Two types of maps were developed: Emergency Operation Center (EOC) maps to be used by civil defense and other emergency managers and simple maps for use by the general public. Maps outlining evacuation routes, shelter locations, and other pertinent information were published in local phone books.

"The Georgia Plan" illustrates how regional planning agencies can be an effective mechanism to help groups and agencies coordinate their emergency preparedness planning efforts. The Georgia experience also shows how a little "creative financing" can go a long way at the local level.

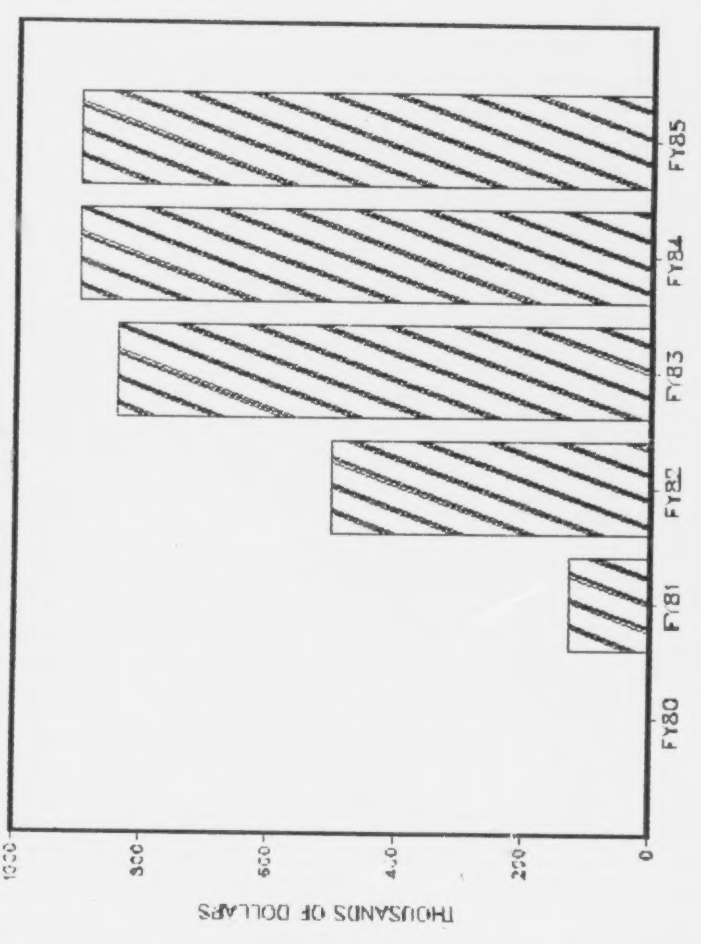
Information about "The Georgia Plan" can be obtained from: The Coastal Area Planning and Development Commission, P. O. Box 1917, Brunswick, Georgia 31521.

Hurricane Monograph Available

FEMA plans to publish a new Hurricane Monograph with the latest information on what is being done throughout the country to promote hurricane awareness and preparedness.

The monograph focuses on the successful efforts of various state and local governments, business, and industry in innovative hurricane awareness/education programs. It also includes summaries of recent research on hurricane risk communication and creative ways to bring together public and private resources in cooperative projects to promote awareness of the hurricane danger.

Available in early August, the monograph will be distributed to state directors in hurricane-prone areas, and to those who previously received a Hurricane Kit. It will also be available from Office of Public Affairs, FEMA, Washington, D.C. 20472.



F.E.M.A. Funding For The
HURRICANE PREPAREDNESS PLANNING PROGRAM

HURRICANE PREPAREDNESS PLANNING PROGRAM
(In thousands of dollars)

HURRICANE RISK AREAS	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY89	FY90
Tampa Bay	75	100								
Georgia Coast	58	75								
Galveston/Houston, TX		100	100							
New Orleans		75		100	50	100				
South Florida		150								
Tri State — FL, AL, MS			215	200	50	100				
Hawaii			100	70		100				
New Jersey			120	70						
Long Island, NY			130							
Puerto Rico/Virgin Is.			50	55	100	40				
Beaumont/Port Arthur, TX				114		80				
Charleston/Myrtle Beach, SC			25	60	100	60				
Corpus Christi, TX			100	90						
Pamlico Sound, NC				55	100	50				
Brownsville, TX/Matamoros, Mexico				55	50	75				
Norfolk/Virginia Beach/Newport News					50	50	75	75	50	
Buzzards Bay/Cape Cod						45	75	75	75	100
Rehoboth/Delaware Coast						50	75	75	75	100
Ocean City/Maryland Coast					55	50	75	75	50	
Connecticut Coast					50	50	75	75	50	
Narragansett Bay/So. Rhode Island					55	50	75	75	50	
Guam/Samoa/Trust Terr.									100	250

Mr. Scheuer. Thank you very, very much, Dr. Speck.

From your vantage point, let me ask you the same question that I asked the witness just before you. From the cost-effectiveness point of view—which this administration is very keenly sensitive to, and properly so—from the point of view of reducing risk and reducing damage and preventing human tragedy on a vast scale, what do you consider or what does your Agency consider to be the most cost-effective approach? Is it better forecasting? Longer period of warning time? Is it improved highway egress from these coastal areas? Is it high-rise buildings? Is it to change human behavior? Or is it a combination of all of these? What do you see as the target of opportunity in substantially reducing the risk of death and property destruction in the event of additional severe hurricanes?

Dr. Speck. Mr. Chairman and members of the committee, I think the chairman gave the best answer when he asked if it was a combination of all of these, because I think it is going to be a combination of all of these. For example, you've built more highways that gave people a new sense of security; what you might well do is find more people moving across those highways to build on those barrier reefs. And you might, in the long run, not have solved your problem; you may have only temporarily addressed it.

It seems to me that we do have to work to advance the scientific frontiers to give us that information that will allow us to improve our warning system. We have to educate people so that they will be responsive to those warnings, and sympathetic with political leaders that may say, you know, "There's a real threat here, but it may not land here, but it could within the next 24 hours"—because what we're talking about when we talk about the 12 hours, we're talking about when you can really be pretty specific. In 24 hours, you can't be quite so specific. It may go one area up the coast or down the other, and that doesn't mean that a warning won't be effective; and I suspect that when you get down to 24 hours, you're going to find people spontaneously evacuating before there is any evacuation plan enacted. Particularly in vacation areas, you're going to find people not coming when they hear of a hurricane threat in the area, or you're going to find people going home early.

So I think it's important that we don't overmagnify the threat that nobody would have the good sense to start leaving before that 12 hours, or avoid coming before that 12 hours, that kind of thing.

Mr. Scheuer. All right. Let me interrupt you because our time is very limited. I want to ask one more question.

NOAA apparently has insufficient funds to complete the evacuation study phase of its storm surge model for 19 of the 22 basins along the Atlantic and Gulf Coast States. What is the effect of not completing these studies? And are there any additional areas, other than the 22 areas designated, that ought to be studied? And would FEMA support additional funding to NOAA to complete these studies?

Dr. Speck. Mr. Chairman and members of the committee, FEMA has participated in phase II funding of some of those studies at this point, and I would anticipate that we would be likely to continue to do some of that assistance where we get involved in the simulations and that sort of thing upon which you can build your preparedness plans.

Mr. **Scheuer**. Our information is that they don't have the funding now to complete their phase II studies. Their computer simulations of storm surge flooding.

Dr. **Speck**. We have been involved directly and indirectly; in some cases, even some Civil Defense moneys have been involved——

Mr. **Scheuer**. Well, would you join——

Dr. **Speck** [continuing]. Through the local governments, money——

Mr. **Scheuer**. Let me ask you a specific question, Dr. Speck. Would you join with them in requesting additional funding if it turns out to be the fact that they don't have sufficient funding now to complete their phase II computer simulations for storm surge flooding?

Dr. **Speck**. Mr. Chairman, that would certainly affect the priorities and how we allocate our moneys.

Mr. **Scheuer**. Would you join with them in asking for additional funding to do this work?

Dr. **Speck**. Mr. Chairman, I think realistically that you know that, as associate director, I don't have the prerogative to say that I'm going to join anybody in asking for additional funding. That is something that ultimately will be——

Mr. **Scheuer**. Do you consider it important?

Dr. **Speck**. Yes. We have allocated those moneys, and with the support of Congress we have sought and received additional funding, and I would expect that we would try to be responsive in the future.

Mr. **Scheuer**. Thank you.

Congressman McGrath.

Mr. **McGrath**. No questions.

Mr. **Scheuer**. Congressman Mike Andrews of Texas.

Mr. **Andrews**. Just a few questions, and I'll try to be very brief.

One of the things that happened, that became very apparent in Alicia, is how important your work is, and I really applaud your efforts, especially in trying to work with local governments. We have a problem that I don't think is unique to the country, but it's very true in our area. There are many communities near Houston, in between Houston and Galveston, small communities; and there is a total lack of communication or plan between those communities in terms of evacuation. Literally, if the mayor of Galveston should determine that his city should evacuate the island along that one artery, there are four or five mayors of smaller cities that have no idea that thousands of people are going to be put on that freeway when he's trying to make his decision as to whether or not the citizens of his community should be evacuated. There's no inventory in our area of emergency equipment, vehicles or generators, and so many small town mayors are left unaware of where to go to get a heavy dump truck that maybe their city doesn't have the funds to buy.

And so I think your efforts are commendable, and I think it's very important that you're doing what you're trying to accomplish.

One of the things that it seemed to me would be appropriate, and one of the problems that I saw, is that you all by law are somewhat hampered in that you literally can't go into an area until the President determines that, in fact, it is a disaster area, until—and I think I'm correct in my assessment of what the law is—the Governor has got to overview the area, request the President, then the President turns to FEMA and has FEMA go in.

Would it not be a good purpose of this committee to review the possibilities of some legislation that would allow the President, on his own prerogative working with FEMA in an area where disaster is imminent, to send in some FEMA representatives, to locate the site, to have that press conference before the storm and not a week after the storm, to notify people where the emergency centers would be in their community, to notify persons what the emergency phone numbers are. Now, a lot of this is done by local governments and, hopefully, by State governments, but a lot of times it's not done.

Would not it be a valuable tool for you to be able to go into an area along the coastline and say, "This will be our major center if the storm strikes. These are the numbers to call. Here are the services that FEMA has available." What we learned from Hurricane Alicia is that many people, quite frankly, don't know what you do; they had never heard of FEMA before and didn't know the services that were offered. Some very basic things that you provide to folks, I think a lot of people just frankly didn't know about; and that created a lag time, especially after a storm when it's terribly, terribly critical that people have the roof put back on their home or have food or medical supplies, or know where to go for the Small Business loan, or what services you provide that are so necessary for folks right after a storm.

I wonder if you would just comment on that thought of mine. Would it be beneficial for you to have some mechanism, were the President to tell you that a storm may be imminent along the Atlantic coast or along the gulf coast, and give you the opportunity to send in a representative or a team, a strike force team, to go into that area, review the situation, make public your suggestions; and, hopefully, if the storm does not strike, while we've spent a little money, we've probably saved valuable time in the wake of a storm trying to do those primarily logistical steps.

I wonder if you would just comment on that suggestion.

Dr. SPECK. Mr. Chairman and Congressman Andrews, I would say that possibly that would have some value to it. It gets into the very delicate area of preempting, to some degree, the Governor's prerogatives in determining whether or not, indeed, there has been a disaster. I would also point out that we don't just sit around waiting, as it were, that our Public Affairs Division, for example, has announcements ready to go; that we don't wait, in essence, to be called by a Governor; when we see a hurricane in the offing, we begin to look to see who we're going to send in there, begin to get ready. We send people in as soon as something like that happens to help do the disaster survey with the Governor, to assist—if they ask us to—in getting the declaration prepared, the request for the declaration prepared. So we don't sit around just waiting until after the disaster takes place and then say, "Well, FEMA better get geared up and go in there."

Whether it would be appropriate for us to announce where there will be the disaster centers open and that sort of thing is something that perhaps we need to review together.

Mr. ANDREWS. Let me just ask you to be specific. Hurricane Alicia, which was over a 3-point storm, hit Galveston. How many days was it before an FEMA office opened in that disaster area?

Dr. SPECK. I don't have the exact date on that, but we can find that for you and submit it for the record.

Mr. ANDREWS. OK. Let me just suggest that it was at least six, and may have been a week after the storm; and I could certainly stand to be corrected. I'd like to see the dates, too.

But would you not agree with me that that's a long time, that those were precious days following the storm? And if we could shorten that window of time, where you could move in by just 1 or 2 days, it would be extremely important.

Dr. SPECK. Yes. In terms of providing emergency assistance, whether it's the corps providing it at the request of FEMA or coming in directly, those kinds of things, obviously we don't wait. You don't have to open a disaster office or center to respond in those kinds of things which are responding to the emergency, where you're involved in flood fighting or what have you.

When it comes to the recovery phase, which is really what the disaster assistance centers are about, time is vital; but in terms of helping public facilities recover, for example, the State and local governments have things they have to do. They have to go out and take a look at what has been lost, they have to get proper engineering estimates of what it's going to cost to make those repairs, and these kinds of things, before they're ready to submit that to FEMA. And so, when you see the public facilities damaged, there is a time in which a number of activities by State and local governments have to take place.

Mr. ANDREWS. It's a good point.

I don't want to take any longer, and I do hope in the future, Mr. Chairman, we can review this area that we're discussing right now because I think it's very important. The FEMA folks want to move in quickly, and I think that's what Dr. Speck is saying. If we can some way, through the hearing process or through the legislative process, assist in closing and narrowing that gap of time from the date of the storm to the date you all are set up and open for business, I think it would benefit everyone.

Thank you, Mr. Chairman.

Mr. SCHEUER. Very good.

Congressman Tom Lewis of Florida.

Mr. LEWIS. Thank you, Mr. Chairman.

Dr. Speck, I have rather a lengthy question. Do you know if south Florida has an evacuation plan, and can you specifically tell me how the Feds, the State, and the locals are organized to respond to hurricane warnings—and, of course, hurricane weather? In other words, who does what?

Dr. SPECK. I am going to ask, Mr. Chairman, that Mr. Krimm, who heads our Natural and Technological Hazards Division, respond to the particulars of the south Florida plan.

Mr. LEWIS. Fine.

Mr. **Krimm**. My name is Richard Krimm. Southeast Florida does have a hurricane preparedness plan. The plan was not developed using the NOAA model; it was developed prior to the incorporation of the NOAA model in our preparedness studies.

Recently I was in Broward County where they had a very large hurricane preparedness day, and in many of the communities in southeastern Florida they do run test evacuations on an annual basis in anticipation of a hurricane. They do use the plans which FEMA helped fund in testing evacuations. They do have routes that are marked where people would evacuate. They try, through public service announcements and so forth, to alert people to the problems of hurricanes and where they should go if and when a hurricane occurs.

Mr. **Lewis**. Are they going to update through the NOAA model in respect to what Dr. Frank said earlier? Because you're talking about the 12-hour plan, and there is no way you can evacuate Fort Lauderdale in 12 hours.

Mr. **Krimm**. That's correct, and we are currently talking with NOAA about that because we had a request about going back. The problem is, there are other areas where we also have to do preparedness plans, but we are working with NOAA trying to maybe go back and use the SLOSH model, and I'd be very glad to keep you apprised of what's happening in that area.

Mr. **Lewis**. Thank you.

Thank you, Mr. Chairman.

Mr. **Scheuer**. Dr. Speck, we appreciate your testimony very much, and we'll have some additional questions for you in writing. Thank you very much.

Dr. **Speck**. Thank you, Mr. Chairman, and I'll be leaving some of these things for the committee.

Mr. **Scheuer**. Excellent.

All right. Now we'll hear from Dave Murray, chairman of the Board of Broadcast Meteorologists and the Meteorologist for "Good Morning, America." We're very happy to have you here today; we know that you've already put in a good 8-hour day by this time, so your prepared testimony will be printed in full as you have prepared it in the record, so why don't you take 5 or 6 minutes and sum up and then I'm sure we'll have some questions for you.

STATEMENT OF DAVE MURRAY, CHAIRMAN OF THE BOARD OF BROADCAST METEOROLOGISTS, AND METEOROLOGIST, "GOOD MORNING, AMERICA"

Mr. **Murray**. Just as a little bit of background, again, I am a meteorologist for ABC television in the category of "Good Morning, America," and also "World News This Morning." Right now I am the chairman of the American Meteorological Society Board of Broadcast Meteorology. In that capacity I represent about 250 meteorologists currently reporting the daily forecast on local television and radio stations across the country. Most of those hold the AMS seal of approval and a bachelor of science degree in meteorology. Personally, I hold both, and also graduate study in the science, and I've been reporting the weather on major market television and radio over the last 8 years.

I have been asked today to address the question, do I think the public is prepared in case a major hurricane hits the coast of the United States? Basically, my answer is no, and hopefully, I will explain here why I feel that way, and maybe some solutions to it.

First of all, I do tend to agree with the theory that hurricanes do hit in cycles, and the east coast, especially, is indeed fortunate to be spared so long. In fact, the time lapse has been so long that most of the age group of majority in this country, now in their thirties, have never really experienced a hurricane except through what they have seen on the news, and we all know that seeing the effects of a hurricane on the television news is quite different from actually being in one.

So when we're talking about a major hurricane, we're talking about the storm hitting the coast with winds possibly up to 200 miles per hour. The storm could bring as much as 15 inches of rain in 48 hours, possibly faster; and as Neil Frank has mentioned, the storm surge, that ocean wall of water that will hit before the center of the storm, could raise the ocean level at least 6 to 10 feet in a half hour. If it hits at high tide and a full moon, conditions will be even worse.

Now, if a hurricane like this hits the area around New York City where 2 to 3 inches of rain causes major street flooding and major delays—and I can attest to that, every time it rains in New York—I'm sure that you can see the tremendous threat to human life, not to mention the damage of property along the coastline. And I can't believe the situation is any different in Boston or Washington, DC or any other coastal city in America.

So do I think the public has a realistic concept of the force of a hurricane? Again, no, I do not. My experience is that the public basically has a "wait and see" attitude when it comes to the weather. Many will wait until the rain really is so bad and so hard that they get scared, jump in their cars, possibly find out they don't have enough gas to get through the traffic they're going to hit; and if this happens, the loss of life could be really greater than we could ever imagine.

Naturally, we have to find ways to avoid this. And I think the solution is twofold. First, the authorities must have the proper evacuation plan that will work, and the public must be educated as to how to prepare for a hurricane.

Second, we must find ways to convince the public that a clear danger actually does exist. If people are not convinced, they will be very slow to react and possibly not react at all.

I will not speak on the topic of evacuation; it's not my area of expertise. But warning the public of severe weather danger is largely the responsibility of the meteorologist, and I will focus the rest of my remarks on that.

Research has proven, at this point, that most people in the country receive their weather information on the television or from the radio. Some people watch the morning news programs just to see if they need to take the umbrella or raincoat to work. So, in a potential hurricane situation, it is likely most people will "stay tuned." The question is, what will they hear, and what will they actually believe?

The standard procedure in a potential hurricane situation is, first, the issuance of a hurricane watch, and then a hurricane warning. The watch would most likely be issued by the National Hurricane Center 36 to 48 hours before the hurricane is expected to hit. The watch tells people there is a possibility, just a possibility, that the hurricane will actually hit, and that preparations should be taken.

It's my experience, though, that people don't pay any attention to watches at all. They may be aware that a watch is in effect, but they tend not to take any action to prepare or evacuate until the warning is issued. I'm talking primarily general public here.

It's a dangerous situation, because preparation in a hurricane situation is much more important than any other weather hazard. Preparation for a hurricane takes longer. Houses need to be boarded up. People need supplies. They need a full tank of gas, water supplies. In a tornado situation, people basically just run to the basement.

Before coming to "Good Morning, America" I spent 7 years in St. Louis, in the tornado belt. People in the tornado belt tend to be more prepared, largely because tornadoes and severe thunderstorms happen many times during the course of a week. And also, I think that preparation for tornadoes is somewhat easier than preparation for a hurricane.

Now, as far as warnings are concerned, people take them a little more seriously. A warning means you are in the path of a hurricane that is about to hit. Under the best forecasting conditions, a warning could possibly be issued 24 hours before the hurricane hits; but given the fact that meteorology is still very much an inexact science, and hurricanes are prone to very erratic movement and unpredictability, it is more likely that the hurricane warning will be issued about 12 hours before it hits.

So the question becomes, can we still get everybody out in time, even if they do believe us? To help clarify the potential danger to authorities and to the public, the National Hurricane Center has recently instituted a system of probability reports. Essentially, the probability that a hurricane will hit is low about 36 to 48 hours before the hurricane, and they will gradually step up to about 70 percent or higher about 10 hours before the forecast time that the hurricane will hit land.

The Hurricane Center suggests this system will help Government decisionmakers. I agree with that. They need to know how long it will take to evacuate certain areas. But the Hurricane Center also suggests that the probability numbers are suitable for the media, to broadcast increasing danger to the public. Overall, I think the new system is a good idea as an in-house forecasting tool for all meteorologists, and may certainly help governmental authorities. But I do not believe that it will be helpful to pass these probabilities to the public in broadcast weather reports. Over the years it has become very clear to me and many meteorologists that the public simply does not understand probability numbers in general. For years we have used numbers concerning the probability of precipitation, that is, the percent that it's going to rain, and the public doesn't seem to care. Very confusing, especially when it comes across on television and radio. Tell somebody there's a 70-percent chance of rain, and the average reaction is, "What does it mean? Is it going to rain, or isn't it?" I found out it's much better to say, "Tomorrow, the morning looks OK; the clouds are going to come up in the afternoon, and by 5 o'clock and after it's going to rain." And chances are, if you live in the particular area, you're going to get wet; better take the umbrella.

People relaxing, watching television, can understand that. There are no numbers involved, and the idea is to make the forecast as simple as possible, but accurate and relatively easy to understand.

So, given the built-in danger of confusion in hurricane forecasting, I do not think it is a good idea to pass on another number to the public. Telling somebody there's a 70-percent chance that a hurricane is going to hit them does not tell them what they need to know, which is that a hurricane will hit between point A and point B, and if you live between those points, you're going to feel the effects of a hurricane. You don't want to leave any doubt in the viewers' minds, and this is the way I think it needs to be done.

Confusion in the public's mind is probably the biggest obstacle we all face to an effective course of hurricane preparedness. As I said earlier, meteorology is an inexact science, and every meteorologist that I'm aware of wants to report the right forecast, whether working for the National Hurricane Center or private weather companies, a TV station, or a radio station. But it is difficult, and meteorologists of varying degrees of competence work for all four entities. No one meteorologist is always right or always wrong. What I am about to tell you may explain why one channel will tell you to take the umbrella in the morning, and the other one might not, and therein shed light on why the public may doubt or be slow to react to a hurricane warning or a hurricane forecast.

When it comes to hurricane forecasting, the public most often has to access four different sources of information. No. 1 is the National Hurricane Center. No. 2 might be a private weather company subscribed to by a radio or TV station. No. 3 is an individual meteorologist on television, like myself. No. 4 is just a weathercaster on television or radio who is not a meteorologist.

First of all, there are some radio and television broadcasters who will take the National Hurricane Center forecast and pass it on directly to the public as it is. But second, there are some radio and TV stations that have hired a private weather company, and their forecast will be passed on as is. Most private weather companies do, overall, a good job; but the reality of broadcasting is that a station will hire a private weather company to give them something more, something different, and something faster than the National Hurricane Center or the National Weather Service in general. A TV station wants to be first and most accurate, and that's why they've hired a private company. Thus there is a built-in motivation for that company to be different and faster than the National Hurricane Center to please the clients. Of course, the weather company will try to be accurate; but when it comes to hurricanes, that company may not have as much forecasting experience or information as the National Hurricane Center. And if the weather company goes with something different than the Hurricane Center, then you can see there certainly is much confusion among the viewers who are watching different channels, not to mention the danger that the private weather company could be wrong.

Now, individual meteorologists on television or radio stations are also around, and it's an increasing trend. More and more television stations are hiring individual meteorologists for their credibility, for their individual forecast, to bring overall quality to the newscast, and for the same motivations as they hire a private weather company to be best and first. Many of these meteorologists are excellent day-to-day forecasters; but again, they probably lack hurricane experience, especially when you consider that there hasn't been a major hurricane on the east coast in about 20 years, and especially when you consider that most meteorologists on television are between the ages of 25 and 40 and haven't experienced a real hurricane. In the heady competition in many local markets, the challenge is to accurately forecast that hurricane path. If one of these meteorologists differs from the National Hurricane Center in an honest effort to be right, or in an effort to make a name for oneself, and he's wrong, the dangerous implications are pretty easy to see.

Finally, we have the weathercasters on TV and radio who are not meteorologists. Many of them will just repeat the National Hurricane Center forecast. Some will have that forecast plus one from a private weather company, and then they will try to interpret the differences between themselves with little or no scientific expertise. Others will report both forecasts individually, and the public will be confused.

Most on-air weather people will take the National Hurricane Center forecast seriously; some will pass it on to the public as is, some will report it and add their own forecast. Others will go solely with a private weather company. Thus, in a single city, it's possible that the public could be exposed to possibly three or four slightly different TV forecasts and maybe 5 to 10 different radio forecasts. Multiply that by all the cities and towns that could be in the path of a major hurricane, and the danger for confusion, as you can see, is our biggest obstacle for the course of safety preparation.

If the evacuation authorities knock on the door of John Jones and tell him he should get out of the area, and John Jones has just watched the forecast on television that made him skeptical of the danger, John Jones might not leave right then. John Smith, next door, he may have watched a different channel, and that convinced him that the danger is close. John Smith is more likely to leave, and on the next day's news, in the gravest of circumstances, we may hear that John Jones and his family didn't make it.

Clearly, the answer to the problem of confusion is some kind of coordination between weather forecasters in the public and private sectors. This topic was recently discussed at the 14th Annual Conference of Broadcast Meteorology, sponsored by the American Meteorological Society last June. At that conference, attended by 250 broadcast meteorologists—including those representing private weather companies—many pointed out their right to have the freedom to report a forecast that they believe is correct, whether it agrees with the National Hurricane Center or not. And in reference to my earlier comments, we cannot discount the possibility that a private meteorologist may be right, and that the National Hurricane Center is wrong.

A certain situation, we can safely say here, is that all entities involved in this dilemma want to report the correct forecast of a hurricane. The question is, how do we do it? The consensus at the conference was that there needs to be more coordination and cooperation between private forecasting and the National Hurricane Center. Neither one should take the opinion that "my forecast is the only one," and then dictate that to other professional forecasters. If either the National Hurricane Center or the private meteorologists adopt that stance, matters will only get worse and the loser will definitely be the public.

Some private meteorologists have come to doubt the product of the National Weather Service, that they put out. In certain parts of the country, private meteorologists have noted a sense of arrogance on the part of the National Weather Service, a feeling that the National Weather Service is the parent telling the child what to do, or not at all. In fact, it is the private weathercasters on television and radio who do more to bring the Weather Service message to the public than anyone else. Also, some private meteorologists believe that recent budget cuts in the National Weather Service have created delays in the dissemination of information and, in some cases, a less accurate forecast from the National Weather Service. Both are factors that make the role of private meteorology more critical in bringing accurate information to the public quickly.

Putting all this together, the need for coordination and cooperation between the National Weather Service and the private meteorologist is greater than ever before. Nothing points this out more than the potential catastrophe of a hurricane.

Personally, in my daily forecasting efforts on ABC with "Good Morning, America," if my analysis of a hurricane situation differed from the National Hurricane Center, I would pick up the phone and call Neil personally and find out why they're going in one direction versus my direction. In other words, let's trade some information. Of course, every private meteorologist in the country just can't do that; the influx of calls would be much too great on the Hurricane Center, a burden on the Government's forecasting center in the middle of crisis. But perhaps if the National Hurricane Center were to dispatch with its forecast some detailed reasons why they were headed that way, then the forecast might be more widely accepted by the private meteorologist; and vice versa, the private meteorologist in the geographic area of the hurricane could be the eyes and the ears of the National Hurricane Center, feeding spotter reports to the center if they felt the information would be taken into consideration.

In summary, do I think the public is prepared in the case of a hurricane hitting the coast? Again, no, I don't. Partly because of a lackadaisical attitude and the lack of information on the part of the public. It's difficult to understand and prepare for something you've never seen or experienced in your lifetime, partly because of a public confusion about many—and sometimes diverse— weather reports they hear.

But on an upbeat note, I do think that the machinery is in place to prepare the public for a hurricane. We have thousands of qualified meteorologists in both the public and private sectors with access to the most sophisticated communications systems in the world. Now all we have to do is fine tune the operation to make sure every part works with the other for the public good.

I'd be happy to answer any questions, if I can.

[The prepared statement of Mr. Murray follows:]

ADDRESS TO SENATE SUBCOMMITTEE
STUDYING HURRICANE PREPAREDNESS

by DAVE MURRAY

METEOROLOGIST, ABC TELEVISION NETWORK "GOOD MORNING AMERICA"
CHAIRMAN
AMERICAN METEOROLOGICAL SOCIETY BOARD OF BRAODCAST METEOROLOGY

GOOD MORNING, I AM HONORED TO BE ADDRESSING THIS PANEL. MY NAME IS DAVE MURRAY, AND I AM THE METEOROLOGIST FOR ABC TELEVISION'S "GOOD MORNING AMERICA" PROGRAM. I AM ALSO CHAIRMAN OF THE AMERICAN METEOROLOGICAL SOCIETY'S BOARD OF BROADCAST METEOROLOGY. IN THAT CAPACITY, I REPRESENT SOME 250 METEOROLOGISTS, MOST OF WHOM ARE CURRENTLY REPORTING DAILY FORECASTS ON LOCAL TELEVISION AND RADIO STATIONS ACROSS THE COUNTRY. MANY HAVE EARNED THE AMS SEAL OF APPROVAL AND HOLD THE BACHELOR OF SCIENCE DEGREE IN METEOROLOGY. PERSONALLY, I HOLD BOTH, INCLUDING GRADUATE STUDY IN METEOROLOGY, AND HAVE BEEN REPORTING THE WEATHER ON MAJOR MARKET TELEVISION AND RADIO FOR EIGHT YEARS.

I HAVE BEEN ASKED TODAY TO ADDRESS THE QUESTION, "DO I THINK THE PUBLIC IS PREPARED IN CASE A HURRICANE HITS THE EASTERN COAST OF THE UNITED STATES?" BASICALLY, MY ANSWER IS NO, AND I WILL ATTEMPT HERE TO EXPLAIN WHY, WITH SOME SUGGESTIONS AS TO WHAT WE CAN DO ABOUT IT.

FIRST OF ALL, I DO TEND TO AGREE WITH THE THEORY THAT HURRICANES HIT IN CYCLES, AND THAT THE EAST COAST IS INDEED FORTUNATE TO HAVE BEEN SPARED SO LONG.

IN FACT, THE TIME LAPSE HAS BEEN SO LONG, THAT MOST OF THE AGE GROUP OF MAJORITY IN THIS COUNTRY, NOW IN THEIR 30'S, HAS NEVER EXPERIENCED ONE, EXCEPT THROUGH WHAT THEY HAVE SEEN ON THE NEWS. AND WE ALL KNOW THAT SEEING THE EFFECTS OF A HURRICANE ON TELEVISION IS QUITE DIFFERENT THAN EXPERIENCING THEM ONESELF.

WHEN WE ARE TALKING ABOUT A MAJOR HURRICANE, WE ARE TALKING ABOUT A STORM HITTING THE COAST, WITH WINDS AS FAST AS A CAR AT THE INDIANAPOLIS 500--- UP TO 200 MILES PER HOUR. THAT STORM WILL BRING AS MUCH AS 15 INCHES OF RAIN IN 48 HOURS, MAYBE FASTER. THAT'S MORE RAIN THAN FELL IN THE WHOLE MONTH OF JULY IN RALEIGH, NORTH CAROLINA. (AND THIS JULY WAS THE WETTEST MONTH ON RECORD THERE.)

THE STORM SURGE... THAT WALL OF OCEAN WATER THAT WILL HIT BEFORE THE CENTER OF THE HURRICANE... WILL RAISE THE OCEAN LEVEL 6 TO 10 FEET IN HALF-AN-HOUR.) AND IF IT HITS AT HIGH TIDE WITH A FULL MOON, IT WILL BE WORSE.

NOW, IF A HURRICANE LIKE THIS HITS NEW YORK CITY WHERE 2 TO 3 INCHES OF RAIN CAUSES MAJOR STORM DRAIN BACK-UP AND STREET FLOODING , I'M SURE YOU CAN SEE THE TREMENDOUS THREAT TO HUMAN LIFE, NOT TO MENTION THE DAMAGE TO PROPERTY ON THE COASTLINE. AND I CAN'T BELIEVE THE SITUATION WOULD BE THAT DIFFERENT IN BOSTON, OR WASHINGTON, D.C.

SO DO I THINK THE PUBLIC HAS A REALISTIC CONCEPT OF THE FORCE POTENTIAL OF A HURRICANE? NO, I DO NOT. MY EXPERIENCE IS THAT THE PUBLIC BASICALLY HAS A " WAIT AND SEE " ATTITUDE WHEN IT COMES TO WEATHER. MANY WILL WAIT UNTIL THE RAIN IS SO BAD, THEY GET SCARED, JUMP IN THEIR CAR, AND FIND OUT THEY DON'T HAVE ENOUGH GAS FOR THE TRAFFIC THEY'LL HIT. IF THIS HAPPENS, THE LOSS OF LIFE COULD BE HIGHER THAN EVER IMAGINED.

NATURALLY, WE MUST FIND WAYS TO AVOID THIS. AND I THINK THE SOLUTION IS TWOFOLD. FIRST, AUTHORITIES MUST HAVE AN EVALUATION PLAN THAT WILL WORK, AND THE PUBLIC MUST BE EDUCATED AS TO HOW TO PREPARE FOR A HURRICANE. SECONDLY, WE MUST FIND WAYS TO CONVINCE THE PUBLIC THAT A CLEAR DANGER EXISTS. IF PEOPLE ARE NOT CONVINCED, THEY WILL

BE SLOW TO REACT, OR WILL NOT REACT AT ALL.

I WILL NOT SPEAK ON THE TOPIC OF EVACUATION, THAT IS NOT MY AREA OF EXPERTISE. BUT WARNING THE PUBLIC OF SEVERE WEATHER DANGER IS LARGELY THE RESPONSIBILITY OF THE METEROLOGIST, AND I WILL FOCUS THE REST OF MY REMARKS ON THAT PROBLEM.

RESEARCH HAS PROVEN, AT THIS POINT, THAT MOST PEOPLE IN THIS COUNTRY RECEIVE THEIR WEATHER INFORMATION FROM TELEVISION OR RADIO. SOME PEOPLE WATCH THE MORNING NEWS PROGRAMS JUST TO SEE WHETHER THEY NEED TO TAKE AN UMBRELLA OR RAIN COAT TO WORK. SO, IN A POTENTIAL HURRICANE SITUATION, IT IS LIKELY MOST PEOPLE WILL " STAY TUNED " AS THEY SAY. THE QUESTION IS, WHAT WILL THEY HEAR, AND WHAT WILL THEY BELIEVE OF WHAT THEY HEAR.

THE STANDARD PROCEDURE IN A POTENTIAL HURRICANE SITUATION IS THE ISSUANCE OF A WATCH, AND THEN A WARNING.. THE WATCH WOULD MOST LIKELY BE ISSUED BY THE NATIONAL HURRICANE CENTER 36 to 48 HOURS BEFORE THE HURRICANE IS EXPECTED TO HIT. THE WATCH TELLS PEOPLE THERE IS A POSSIBILITY THE HURRICANE WILL HIT, AND THEY SHOULD BE PREPARED TO TAKE ACTION.

THE WATCH MAY COVER AN AREA FROM NEWPORT, RHODE ISLAND TO ATLANTIC CITY, NEW JERSEY, OR FROM NEWPORT NEWS, VIRGINIA TO WASHINGTON, D.C. WHEREVER IT IS, IT IS MY EXPERIENCE, THAT PEOPLE JUST DON'T PAY REAL ATTENTION TO WATCHES. THEY MAY BE AWARE A WATCH IS IN EFFECT, BUT THEY TEND NOT TO TAKE ANY ACTION TO PREPARE OR EVACUATE UNTIL A WARNING IS ISSUED. THIS IS DANGEROUS BECAUSE PREPARATION IS MORE IMPORTANT IN A HURRICANE SITUATION THAN IN ANY OTHER WEATHER POSSIBILITY. PREPARATION TAKES LONGER FOR A HURRICANE. THE HOUSE NEEDS TO BE BOARDED UP, AND PEOPLE NEED SUPPLIES LIKE GASOLINE AND WATER. IN A TORNADO SITUATION, PEOPLE CAN JUST RUN TO THE BASEMENT. AND, AS AN ASIDE, PEOPLE IN THE TORNADO BELT TEND TO BE MORE PREPARED, LARGELY BECAUSE TORNADOES HAPPEN MORE FREQUENTLY THAN HURRICANES AND PREPARATION IS EASIER.)

PEOPLE TEND TO TAKE WARNINGS MORE SERIOUSLY. A WARNING MEANS THAT FORECASTING TO THE BEST OF OUR ABILITY, (IN THIS CASE, THE NATIONAL HURRICANE CENTER) YOU'RE IN THE PATH OF A HURRICANE THAT IS ABOUT TO HIT. UNDER THE BEST FORECASTING CONDITIONS, A WARNING MAY BE ISSUED 24 HOURS BEFORE THE HURRICANE HITS. BUT GIVEN THE FACT THAT METEOROLOGY IS STILL AN INEXACT SCIENCE, AND HURRICANES ARE PRONE TO ERRATIC MOVEMENT

AND UNPREDICTIBILITY, IT IS MORE LIKELY THAT A WARNING WILL BE ISSUED ABOUT TWELVE HOURS BEFORE THE HURRICANE HITS. AND THEN THE QUESTION BECOMES, CAN WE STILL GET EVERYBODY OUT IN TIME EVEN IF THEY DO BELIEVE US!

TO HELP CLARIFY THE POTENTIAL DANGER TO AUTHORITIES AND THE PUBLIC, THE NATIONAL HURRICANE CENTER HAS RECENTLY INSTITUTED A SYSTEM OF PROBABILITY REPORTS. ESSENTIALLY, THE PROBABILITIES THAT A HURRICANE WILL HIT WILL BE LOW 36 TO 48 HOURS BEFORE THE HURRICANE. AND THEY WILL GRADUALLY INCREASE TO 70 PER CENT ABOUT 10 HOURS BEFORE THE FORECASTED TIME THE HURRICANE WILL HIT LAND. THE HURRICANE CENTER SUGGESTS THIS SYSTEM WILL HELP GOVERNMENT DECISION-MAKERS WHO KNOW HOW LONG IT WILL TAKE TO EVACUATE A CERTAIN AREA. BUT THE HURRICANE CENTER ALSO SUGGESTS THAT THE PROBABILITY SYSTEM IS EVEN MORE SUITABLE FOR THE MEDIA TO USE TO BROADCAST INCREASING DANGER TO THE PUBLIC.

OVERALL, I THINK THIS NEW SYSTEM IS A GOOD IDEA, AS AN IN-HOUSE FORECASTING TOOL FOR METEOROLOGISTS, AND IT MAY CERTAINLY HELP GOVERNMENTAL AUTHORITIES. BUT, I DO NOT BELIEVE IT WILL BE HELPFUL TO PASS ON THESE PROBABILITIES TO THE PUBLIC IN BROADCAST WEATHER REPORTS. OVER THE YEARS, IT HAS BECOME CLEAR TO ME THAT THE PUBLIC DOES NOT UNDERSTAND PROBABILITY

NUMBERS IN GENERAL. FOR YEARS, WE HAVE USED NUMBERS CONCERNING THE PROBABILITY OF PRECIPITATION, I.E. THE PER CENT CHANCE THAT IT WILL RAIN. AND THE PUBLIC DOESN'T SEEM TO CARE, IT'S TOO CONFUSING ON TELEVISION. TELL SOMEBODY THERE'S A 70 PER CENT CHANCE OF RAIN, AND THE AVERAGE REACTION IS, "WHAT DOES THAT MEAN? IS IT REALLY GOING TO RAIN OR NOT?" I HAVE FOUND IT IS MUCH BETTER TO SAY, "TOMORROW, THE MORNING LOOKS OK, BUT IN THE AFTERNOON IT WILL CLOUD UP, AND THEN IN THE LATE AFTERNOON, IT WILL DEFINITELY RAIN IN PARTS OF OUR AREA, AND THERE'S A GOOD CHANCE YOU'LL GET HIT BY IT." PEOPLE, RELAXING, WATCHING TELEVISION CAN UNDERSTAND THAT! THERE ARE NO NUMBERS. THE IDEA IS TO MAKE THE FORECAST AS SIMPLE AS POSSIBLE, BUT ACCURATE AND EASY TO UNDERSTAND.

SO, GIVEN THE BUILT-IN DANGER OF CONFUSION IN HURRICANE FORECASTING, I DO NOT THINK IT IS A GOOD IDEA TO PASS ON ANOTHER NUMBER TO THE PUBLIC. TELLING SOMEONE THERE'S A 70 PER CENT CHANCE A HURRICANE WILL HIT THEM, DOES NOT TELL THEM WHAT THEY NEED TO KNOW, WHICH IS THAT A HURRICANE WILL HIT BETWEEN POINT A AND POINT B, AND IF YOU LIVE BETWEEN THESE POINTS YOU'RE GOING TO FEEL THE EFFECT OF A HURRICANE. YOU DON'T WANT TO LEAVE ANY DOUBT IN THE VIEWERS MIND. (THE OTHER PROBLEM WITH THE PROBABILITY SYSTEM BEING

REPORTED TO THE PUBLIC IS THAT THEY MIGHT CONFUSE IT WITH THE PROBABILITY OF PRECIPITATION NUMBER, AND THERE IS A BIG DIFFERENCE BETWEEN BEING HIT BY A HURRICANE AND BEING RAINED ON.)

CONFUSION IN THE PUBLIC'S MIND IS THE BIGGEST OBSTACLE WE ALL FACE TO AN EFFECTIVE COURSE OF HURRICANE PREPAREDNESS. AS I SAID EARLIER, METEOROLOGY IS AN INEXACT SCIENCE, AND EVERY METEOROLOGIST I AM AWARE OF WANTS TO REPORT THE ONE TRUE AND RIGHT FORECAST, WHETHER HE OR SHE WORKS FOR THE NATIONAL HURRICANE CENTER, A PRIVATE WEATHER COMPANY, A TV STATION, OR A RADIO STATION. BUT THAT IS DIFFICULT AND METEOROLOGISTS OF VARYING DEGREES OF COMPETENCE WORK FOR ALL FOUR ENTITIES. NO ONE METEOROLOGIST IS ALWAYS RIGHT OR ALWAYS WRONG. WHAT I AM ABOUT TO TELL YOU MAY SHED LIGHT ON WHY ONE CHANNEL WILL TELL YOU TO TAKE AN UMBRELLA IN THE MORNING, AND THE OTHER MIGHT NOT, AND THEREIN SHED LIGHT ON WHY THE PUBLIC MAY DOUBT OR BE SLOW TO REACT TO A HURRICANE FORECAST.

WHEN IT COMES TO HURRICANE FORECASTING, THE PUBLIC MOST OFTEN HAS ACCESS TO BASICALLY FOUR SOURCES OF INFORMATION.

1) THE NATIONAL HURRICANE CENTER.

2) A PRIVATE WEATHERCOMPANY SUBSCRIBED TO BY A RADIO OR TV STATION

3) AN INDIVIDUAL METEOROLOGIST ON TV OR RADIO.

AND 4) A WEATHERCASTER ON TV OR RADIO WHO IS NOT A METEOROLOGIST.

FIRST OF ALL, THERE ARE SOME RADIO AND TELEVISION BROADCASTERS WHO WILL TAKE THE NATIONAL HURRICANE CENTER FORECAST AND PASS IT ON TO THE PUBLIC AS IS. BUT SECONDLY, THERE ARE SOME RADIO AND TELEVISION STATIONS THAT HAVE HIRED A PRIVATE WEATHER COMPANY, AND THEIR FORECAST WILL BE PASSED ON AS IS. MOST PRIVATE WEATHER COMPANIES DO A GOOD JOB. BUT, THE REALITY OF BROADCASTING IS THAT A STATION WILL HIRE A PRIVATE WEATHER COMPANY TO GIVE THEM SOMETHING MORE, SOMETHING DIFFERENT, AND PARTICULARLY SOMETHING FASTER THAN THE NATIONAL HURRICANE CENTER OR WEATHER SERVICE IN GENERAL. A TV STATION WANTS TO BE FIRST, AND MOST ACCURATE, AND THAT'S WHY THEY HIRE A PRIVATE WEATHER COMPANY. THUS THERE IS A BUILT IN MOTIVATION FOR THAT WEATHER COMPANY TO BE DIFFERENT AND FASTER THAN THE NATIONAL HURRICANE CENTER TO PLEASE THE CLIENTS. OF COURSE, THE WEATHER COMPANY WILL TRY TO BE ACCURATE, BUT WHEN IT COMES TO HURRICANES, THAT COMPANY MAY NOT HAVE AS MUCH FORECASTING EXPERIENCE OR INFORMATION AS THE NATIONAL HURRICANE CENTER. AND IF THAT WEATHER COMPANY GOES WITH SOMETHING DIFFERENT THAN THE HURRICANE CNETER, THEN THERE IS CERTAINLY CONFUSION AMONG THE VIEWERS WHO WATCH DIFFERENT CHANNELS, NOT TO MENTION THE DANGER OF THE PRIVATE WEATHER COMPANY BEING WRONG.

NOW, INDIVIDUAL METEOROLOGISTS ON TELEVISION AND RADIO STATIONS. THIS IS AN INCREASING TREND...TELEVISION STATIONS USED TO HIRE WEATHER PEOPLE SOLELY ON THE BASIS OF ON AIR PERFORMANCE, REGARDLESS OF SCIENTIFIC EXPERTISE. THE PROFESSION HAS COME A LONG WAY FROM THE TV WEATHER CLOWNS AND SO-CALLED WEATHERGIRLS OF THE 1960'S AND EARLY 70'S...AND I WOULD LIKE TO NOTE HERE THERE ARE SOME VERY WELL QUALIFIED FEMALE METEOROLOGISTS ON TELEVISION TODAY. MORE AND MORE TELEVISION STATIONS ARE HIRING METEOROLOGISTS FOR THE CREDIBILITY THEIR INDIVIDUAL FORECASTS BRING TO THE OVERALL NEWSCAST... AND FOR THE SAME MOTIVATIONS AS THEY HIRE A PRIVATE WEATHER COMPANY..TO BE THE BEST AND FIRST. MANY OF THESE METEOROLOGISTS ARE EXCELLENT DAY TO DAY FORECASTERS, BUT AGAIN THEY PROBABLY LACK HURRICANE EXPERIENCE, ESPECIALLY WHEN YOU CONSIDER THERE HASN'T BEEN A MAJOR HURRICANE ON THE EAST COAST IN 20 YEARS, AND ESPECIALLY WHEN YOU CONSIDER THAT MOST OF THESE METEOROLOGISTS ON TELEVISION ARE BETWEEN THE AGES OF 25 AND 40 AND HAVEN'T EXPERIENCED A HURRICANE. BUT IN THE HEADY COMPETITION IN MANY LOCAL MARKETS, THE CHALLENGE IS TO ACCURATELY FORECAST A HURRICANE PATH - NOT ONLY TO BE FIRST, BUT FOR PERSONAL SATISFACTION. AND IF ONE OF THESE METEOROLOGISTS DIFFERS FROM THE NATIONAL HURRICANE CENTER IN AN HONEST EFFORT TO BE RIGHT, OR IN AN EFFORT TO MAKE A NAME FOR HIMSELF, AND HE'S WRONG...THE DANGEROUS IMPLICATIONS ARE

CLEAR.

FINALLY, WE HAVE THE WEATHERCASTERS ON TV AND RADIO WHO ARE NOT METEOROLOGISTS. MANY OF THEM WILL JUST REPEAT THE NATIONAL HURRICANE CENTER FORECAST. BUT SOME WILL HAVE THAT FORECAST, PLUS THE ONE FROM A PRIVATE WEATHER COMPANY, AND TRY TO INTERPRET THE DIFFERENCES THEMSELVES WITH LITTLE OR NO SCIENTIFIC EXPERTISE. OTHERS WILL REPORT BOTH FORECASTS INDIVIDUALLY AND THE PUBLIC WILL BE CONFUSED. AND THAT IS THE MOST LIKELY PROBLEM IN ALL THESE SITUATIONS I DESCRIBE...MOST ON-AIR WEATHER PEOPLE WILL TAKE THE NATIONAL HURRICANE CENTER FORECAST SERIOUSLY, SOME WILL PASS IT ON TO THE PUBLIC AS IS, SOME WILL REPORT IT AND ADD THEIR OWN FORECAST, OTHERS WILL GO SOLELY WITH A PRIVATE FORECAST OR WEATHER COMPANY.

THUS, IN A SINGLE CITY, THE PUBLIC IS EXPOSED TO POSSIBLY THREE OR FOUR SLIGHTLY DIFFERENT TV FORECASTS, PLUS MAYBE FIVE TO TEN RADIO FORECASTS... MULTIPLY THAT BY ALL THE CITIES AND TOWNS THAT COULD BE IN THE PATH OF A HURRICANE...AND THE DANGER FOR CONFUSION IS THE BIGGEST OBSTACLE TO A PLANNED COURSE OF SAFETY PREPARATION.

IF THE EVACUATION AUTHORITIES KNOCK ON THE DOOR OF JOHN JONES AND TELL HIM HE SHOULD GET OUT OF THE AREA, AND JOHN JONES HAS JUST WATCHED A FORECAST

THAT MADE HIM SKEPTICAL OF THE DANGER, JOHN JONES MAY NOT LEAVE RIGHT THEN. JOHN SMITH, NEXT DOOR, MAY HAVE WATCHED A DIFFERENT CHANNEL THAT CONVINCED HIM THE DANGER IS CLOSE. JOHN SMITH IS MORE LIKELY TO LEAVE. AND ON THE NEXT DAY'S NEWS, IN THE GRAVEST OF CIRCUMSTANCES, WE MAY HEAR THAT JOHN JONES AND HIS FAMILY DIDN'T MAKE IT.

CLEARLY THE ANSWER TO THIS PROBLEM OF CONFUSION IS IN SOME KIND OF COORDINATION BETWEEN WEATHER FORECASTERS IN THE PUBLIC AND PRIVATE SECTORS. THIS TOPIC WAS DISCUSSED AT THE 14TH ANNUAL CONFERENCE ON BROADCAST METEOROLOGY, SPONSORED BY THE AMERICAN METEOROLOGICAL SOCIETY, LAST JUNE. AT THAT CONFERENCE, ATTENDED BY SOME 250 BROADCAST METEOROLOGISTS, INCLUDING THOSE REPRESENTING PRIVATE WEATHER COMPANIES, MANY POINTED OUT THEIR RIGHT TO HAVE THE FREEDOM TO REPORT A FORECAST THAT THEY BELIEVE IS CORRECT, WHETHER IT AGREES WITH THE NATIONAL HURRICANE CENTER OR NOT. AND IN REFERENCE TO MY EARLIER COMMENTS, WE CANNOT DISCOUNT THE POSSIBILITY THAT A PRIVATE METEOROLOGIST MAY BE RIGHT, AND THE NATIONAL HURRICANE CENTER WRONG OM A CERTAIN SITUATION. WE CAN SAFELY SAY HERE, THAT ALL ENTITIES INVOLVED IN THIS DILEMMA WANT TO REPORT THE ONE TRUE AND CORRECT FORECAST OF A HURRICANE. THE QUESTION IS HOW? AND THE CONSENSUS AT THE CONFERENCE WAS THAT THERE NEEDS

TO BE MORE COORDINATION AND COOPERATION BETWEEN THE PRIVATE FORECASTING SECTOR AND THE NATIONAL HURRICANE CENTER. NEITHER ONE SHOULD TAKE THE OPINION THAT MY FORECAST IS THE ONLY ONE THERE IS AND THEN DICTATE THAT TO OTHER PROFESSIONAL FORECASTERS. IF EITHER THE NATIONAL HURRICANE CENTER OR THE PRIVATE METEOROLOGISTS ADOPT THAT STANCE, THEN MATTERS WILL ONLY GET WORST AND THE LOSER WILL BE THE PUBLIC.

SOME PRIVATE METEOROLOGISTS HAVE COME TO DOUBT THE PRODUCT THE NATIONAL WEATHER SERVICE PUTS OUT. IN CERTAIN PARTS OF THE COUNTRY, PRIVATE METEOROLOGISTS HAVE NOTED A SENSE OF ARROGANCE ON THE PART OF THE NATIONAL WEATHER SERVICE, A FEELING THAT THE NATIONAL WEATHER SERVICE IS THE PARENT TELLING THE CHILD TO DO IT OUR WAY OR NOT AT ALL WHEN, IN FACT, IT IS THE PRIVATE WEATHERCASTERS ON TELEVISION AND RADIO WHO DO MORE TO BRING THE WEATHER SERVICE MESSAGE TO THE PUBLIC THAN ANYONE ELSE. ALSO, SOME PRIVATE METEOROLOGISTS BELIEVE THAT RECENT BUDGET CUTS IN THE NATIONAL WEATHER SERVICED HAVE CREATED DELAYS IN THE DISSEMINATION OF INFORMATION AND IN SOME CASES A LESS ACCURATE FORECAST FROM THE NATIONAL WEATHER SERVICE. BOTH ARE FACTORS THAT MAKE THE ROLE OF THE PRIVATE METEOROLOGIST MORE CRITICAL IN BRINGING ACCURATE INFORMATION TO THE PUBLIC QUICKLY.

PUTTING ALL THIS TOGETHER, THE NEED FOR COORDINATION AND COOPERATION BETWEEN THE NATIONAL WEATHER SERVICE AND THE PRIVATE METEOROLOGIST IS GREATER THAN EVER BEFORE. NOTHING POINTS OUT THIS NEED MORE THAN THE POTENTIAL CATASTROPHE OF A HURRICANE.

PERSONALLY, IN MY DAILY FORECASTING EFFORTS FOR ABC TELEVISIONS, "GOOD MORNING AMERICA", IF MY ANALYSIS OF A HURRICANE SITUATION DIFFERED FROM THE NATIONAL HURRICANE CENTER FORECAST, I WOULD CALL NEIL FRANK TO FIND OUT WHY THEY'RE GOING IN ONE DIRECTION VERSUS THE DIRECTION I SEE. IN OTHER WORDS, LET'S TRADE SOME INFORMATION. OF COURSE, EVERY PRIVATE METEOROLOGIST IN THE COUNTRY CAN'T DO THAT, THE INFLUX OF CALLS MIGHT BE TOO BIG A BURDEN ON A GOVERNMENT FORECASTING CENTER IN THE MIDDLE OF A CRISIS. BUT, PERHAPS, IF THE NATIONAL HURRICANE CENTER WERE TO DISPATCH WITH ITS FORECAST SOME REASONS WHY THEY'RE GOING THE WAY THEY ARE, THEN THEIR FORECAST MIGHT BE MORE WIDELY ACCEPTED BY PRIVATE METEOROLOGISTS. VICE VERSA, PRIVATE METEOROLOGISTS IN THE GEOGRAPHIC AREA OF THE HURRICANE COULD BE THE EYES AND EARS OF THE NATIONAL HURRICANE CENTER.... FEEDING SPOTTER REPORTS TO THE CENTER IF THEY FELT THE INFORMATION WOULD BE TAKEN INTO CONSIDERATION.

IN SUMMARY, DO I THINK THE PUBLIC IS PREPARED IN CASE A HURRICANE HITS? NO, I DON'T. PARTLY BECAUSE OF A LACKIDAISICAL ATTITUDE AND LACK OF INFORMATION ON THE PART OF THE PUBLIC...IT IS DIFFICULT TO UNDERSTAND AND PREPARE FOR SOMETHING YOU'VE NEVER SEEN OR EXPERIENCED IN YOUR LIFETIME. PARTLY BECAUSE OF A PUBLIC CONFUSION ABOUT THE MANY AND SOMETIMES DIVERSE WEATHER REPORTS THEY HEAR.

BUT I DO THINK THE METEOROLOGICAL MACHINERY IS IN PLACE TO PREPARE THE PUBLIC FOR A HURRICANE. WE HAVE THOUSANDS OF QUALIFIED METEOROLOGISTS IN BOTH THE PUBLIC AND PRIVATE SECTORS, WITH ACCESS TO THE MOST SOPHISTICATED COMMUNICATIONS SYSTEMS IN THE WORLD. NOW ALL WE HAVE TO DO IS FINE TUNE THE OPERATION TO MAKE SURE EVERY PART WORKS WITH THE OTHER FOR THE PUBLIC GOOD.

Mr. SCHEUER. Well, thank you very much. How do you fine tune it, while still leaving room for diversity and difference of opinion?

Mr. MURRAY. I think you fine tune it in the case of a hurricane situation by making sure that the private meteorologists and the National Hurricane Center are pretty much attuned to exactly where they're headed. I have the utmost confidence in Neil Frank and his people who work for him, and I would personally, most likely, go with whatever the National Hurricane Center is forecasting. I'm one of those groups; I have never really experienced a hurricane. I was born in 1953 and went through that, so my parents tell me, up in the New England area. I don't remember that, and even if I was a teenager, I don't think I would remember what my parents did to try to protect me in a situation like that.

So the education, I think, is extremely important in getting the information across, and maybe some type of in-house computer system of some kind that the National Weather Service can directly talk to us—not the public in general—because you always have the problem of, if the Hurricane Center sends out a lot of detailed information to anybody who wants it, then the information could even get more confusing. But what we would be looking for is some good, solid, hardcore information from the Hurricane Center to say, "This is why we honestly think the storm is going to hit between point A and point B, and this is why we think you ought to go with our forecast."

Mr. **Scheuer**. What do you consider the greatest national need to be to make you more effective in the warnings and the cautions that you give?

Mr. **Murray**. I think right now it is more or less an education process, more than anything else. The forecasting—of course, we're always striving to get a better forecast; but at the same time, we also realize we have to live within budgets. But I think the education is the biggest problem. I think if you ask the average person on the street what to do in a hurricane, they're going to say, "I have no idea." And if you say you need to get out in 12 hours or 6 hours or whatever, what do they do? "I have no idea." And if you ask them what a hurricane is, how deadly is it, I don't think many people have the concept of how deadly it is, much the same with a tornado.

Mr. **Scheuer**. Mr. Murray, in order to evacuate communities we're going to have to stretch the warning time. And as we stretch the warning time, then our accuracy gets a little fuzzy and there will be an increasingly large number of false evacuations. Now, you'd probably be an expert witness on what the reaction of people would be who are falsely evacuated or who are told to skeedaddle out of the area, but fast, with their kids, and lock up their homes, and put up the storm windows, and then find that nothing very much happened.

What's the answer to this dilemma of wanting a longer time to evacuate people, but knowing, as the timeframe gets longer, the accuracy gets a little shorter and fuzzier?

Mr. **Murray**. I think it's a problem that probably has no solution at all. It's always going to be there. Again, let me go back to my experience in the tornado belts. Most people in the Midwest know what a tornado is; they've seen the destruction, many first hand. That differs from the hurricane. But at the same time, day after day—I had a stretch 1 week in St. Louis where I think we had severe thunderstorm weather every day of the week, at the station 24 hours a day. A tornado, though, could hit that side of the room and not affect anybody on that side of the room.

So you're always going to have the problem of possibly crying wolf. Somewhere, though, there's going to be a break point in the public's mind and, also I think, in the forecaster's mind, that this is a serious situation. I think if we get the point across that this is a big storm—and I don't think we have to do it by numbers; I don't think we have to say it's a No. 3 or No. 4 or No. 5 storm; I think if we say it's a giant hurricane with winds up to 150 miles per hour, 180 miles per hour, it's got extremely heavy rains with it, there's an incredible storm surge with it—I think the public is going to say, "OK, now tell me what to do." And, possibly, "Tell me what to do before I really need to think about it."

Mr. **Scheuer**. Thank you very much.

Congressman Andrews.

Mr. **Andrews**. Thank you, Mr. Chairman.

I wonder if you would elaborate just a little bit more on your opinions about the ranking system of hurricanes. I know you were here earlier, but I mentioned that one of the problems that we had with Alicia was that it was rated as a 1; and then suddenly, within 45 minutes, it was a 3.5 when it struck land.

Is there a problem with that? Has that system worked? Do you endorse it, or what changes would you recommend?

Mr. MURRAY. I think the problem exists the same with the probability forecast. I think what happened in your part of the country with Alicia is going to happen all over the country, coastalwise, if we continue with the number process. You rate something 1 to 5, 1 to 10, however you rate it, you say, "Hey, No. 1, No. 2 is coming," especially if the viewers or the people who live in that area don't quite know what a hurricane is. If you say, "Hey, you know, out of a scale of 5, a No. 1 or a No. 2 is coming," then they'll say, "Well, that's not bad; I think my house can stand that. So I close the windows and maybe prepare myself to be without electricity for 12 hours," or something like that.

I think that is probably going to be a deadly mistake when a rather big storm comes in. There's nothing that could have stopped Alicia from all of a sudden becoming a 4 or a 5; I mean, it was a monster hurricane in the gulf, and that part of the country, in my opinion, lucked out. It really looked like it was going to be much worse than it was, all of a sudden, as it started to develop very, very quickly.

Mr. ANDREWS. That's all I have, Mr. Chairman.

Mr. SCHEUER. Thank you.

Mr. Murray, thank you very, very much. It's been a pleasure having you here. We feel as if you're an old friend of ours. You come to visit us every morning regularly, and it will be even more fun to watch you from now on.

Thanks so much.

Mr. MURRAY. Thank you.

Mr. SCHEUER. All right. We will now have our next panel: Dr. James Mitchell of Rutgers University, and Ms. Ruth Ehinger, Division of Coastal Resources of the Department of Environmental Protection, State of New Jersey.

All right. For both of you, your prepared testimony will be printed in full in the record, so I would ask you each to sum up your testimony in 5 or 6 minutes and, as you've noted with the other witnesses, we'll surely have some questions for you.

Dr. Mitchell, why don't you proceed?

STATEMENT OF JAMES K. MITCHELL, RUTGERS UNIVERSITY

Dr. MITCHELL. Good morning.

I have been studying natural hazards in coastal areas for the past 15 years, throughout the United States, and since 1980 that research has focused on the evacuation of New Jersey communities that are at risk to hurricanes. I have just completed what I think is probably the first hurricane evacuation study of any comprehensiveness, which I would like to also enter into the record as part of this testimony.

[The study mentioned above follows:]

No. 21

HURRICANE EVACUATION IN COASTAL NEW JERSEY

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The barrier islands, barrier beaches and low lying mainland coasts of New Jersey's oceanfront counties are intrinsically hazardous and vulnerable places. Seasonal storms and long term erosion threaten most locations with floods, wind damage and receding shorelines. The physical severity of hazard is compounded by dense patterns of permanent settlement, vast influxes of summer visitors, confined island spaces, weakened natural defenses and poor access to safer mainland locations. Hurricanes pose the most serious natural threat but the risks are not confined to natural phenomena. Nuclear power stations, busy ocean shipping lanes, offshore oil and gas exploration and hazardous material spills pose additional threats.

From the standpoint of preserving human safety, evacuation of threatened populations is the single most important element of the complex protection strategies that are employed against hurricanes and other hazards. This report addresses the subject of hurricane evacuation and the related topics of public awareness of hazard and public responses to emergency management programs in oceanfront areas.

THE RANGE OF HAZARDOUS AREAS*

The general pattern of natural hazard in coastal New Jersey is largely a function of three major variables: (1) areas susceptible to flooding; (2) areas lacking protective sand dunes; and (3) areas suffering actual shore erosion. People who occupy low lying communities that lack a protective screen of sand dunes and experience actual shoreline erosion are likely to be among the first to require evacuation in the face of threatening storms. They are also the communities most at risk to hurricane wind damage.

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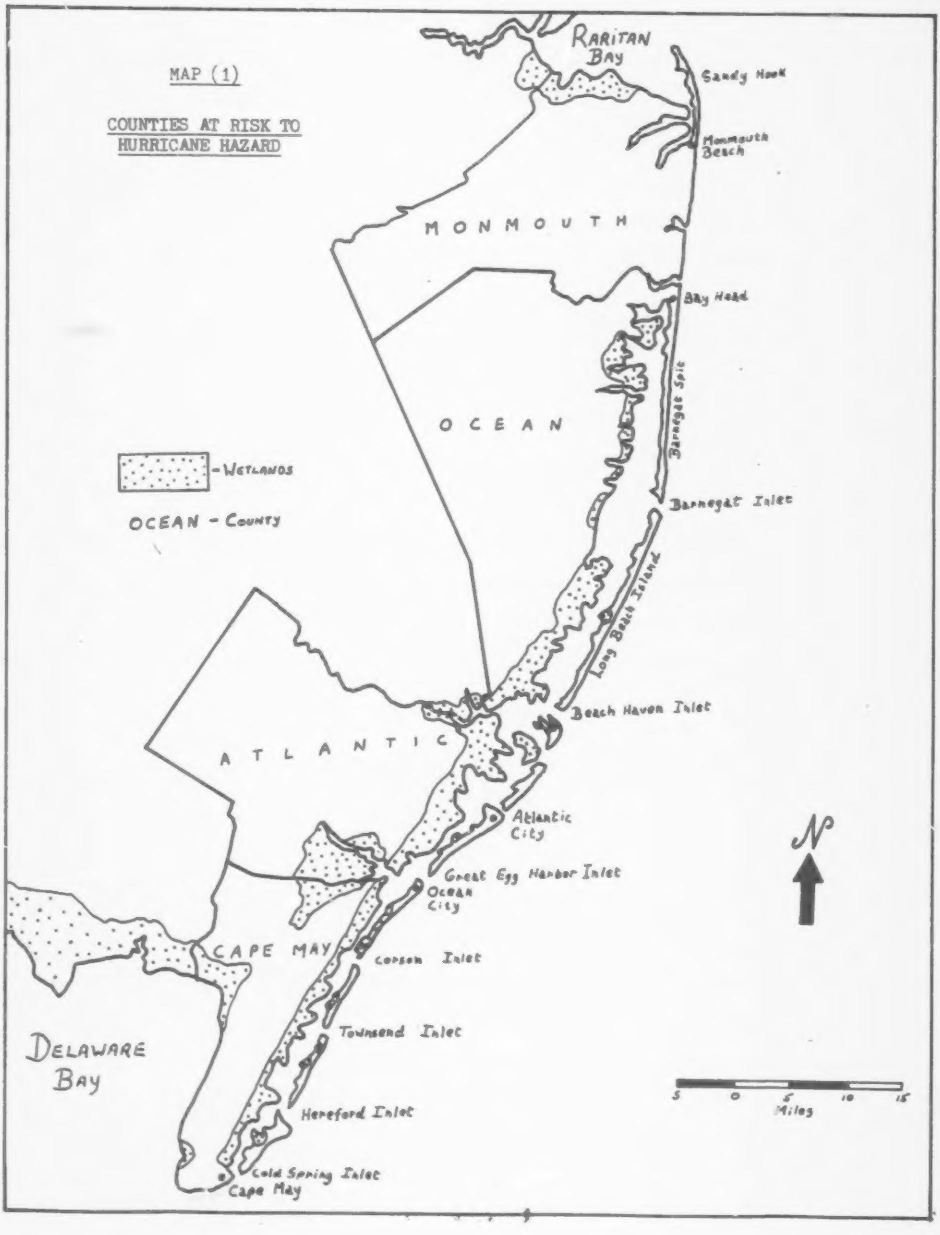
*As this study was being completed, NOAA's SLOSH model (i.e. Sea, Lake and Overland Surges from Hurricanes), which predicts hurricane winds, storm surge heights, and inundation areas, became operational for Delaware Bay and coastal New Jersey (December, 1983). A similar (overlapping) application of this model to New York, Long Island and coastal New Jersey is due to be operational at the end of 1984. SLOSH model simulations have not been used here but should be included in future hurricane risk analyses for New Jersey.

Given the possibility of hurricane surges in excess of 20 feet, no part of the New Jersey oceanfront can be considered entirely safe from life-threatening storms.[1] However, most occupants of the 19 mile long mainland shorefront between Monmouth Beach and Bay Head occupy higher ground behind 15-25 foot bluffs, and could be evacuated relatively quickly if the need arose. (Map 1) The remaining 105 miles of shorefront face greater risks because they include two major sandspits (Sandy Hook, Barnegat spit) and a chain of low lying barrier islands backed by extensive coastal wetlands. Together with other Atlantic and Gulf coast barrier islands the U.S. government has judged this area to be "... hazardous and expensive for human habitation and development."[2] As a first step toward reducing federal subsidies to barrier island development it was decided to end sales of Federal flood insurance for new structures on undeveloped barrier islands, beginning October 1, 1983.[3] Although none of the New Jersey coast was designated "undeveloped" this federal initiative underscores the general hazardousness of the state's barrier island coast. Nevertheless, it is possible to make distinctions among areas of differing exposure to hazard. These can help to identify locations with the highest potential for developing evacuation problems.

COASTAL FLOODING

Information about flood prone areas that may require evacuation is available from a variety of sources. Major documentation is provided by the New Jersey Department of Environmental Protection's Wetlands Mapping Program and the Federal Emergency Management Agency's flood insurance rate maps. Additional sources include NOAA Storm Evacuation Maps, U.S. Soil Conservation Service maps, county plans and inundation maps for individual storms (e.g. March, 1962; Hurricane Belle, 1976).[4] These data indicate that all coastal wetlands lie within


MAP (1)
COUNTIES AT RISK TO HURRICANE HAZARD
- WETLANDS
OCEAN - County
RARITAN BAY
Sandy Hook
Monmouth Beach
MONMOUTH
Bay Head
Barnegat Spit
OCEAN
Barnegat Inlet
Long Beach Island
Beach Haven Inlet
ATLANTIC
Atlantic City
Great Egg Harbor Inlet
Ocean City
CAPE MAY
Corson Inlet
Townsend Inlet
Hereford Inlet
Cold Spring Inlet
Cape May
DELAWARE BAY
N
5
0
5
10
15
Miles

the 100 year floodplain and only the highest coastal dunes protrude above it.[5] However, there is reason to believe that such maps underestimate the full extent of flood potential. Recent inclusion of "wave wash" elevations in flood hazard areas probably puts all oceanfront areas on barrier islands in high risk zones.[6] A National Academy of Sciences study of computer models used to calculate flood probability levels, also casts doubt on their accuracy.[7] It may be prudent to regard the entire barrier island and barrier beach region as lying within the 100 year floodplain.

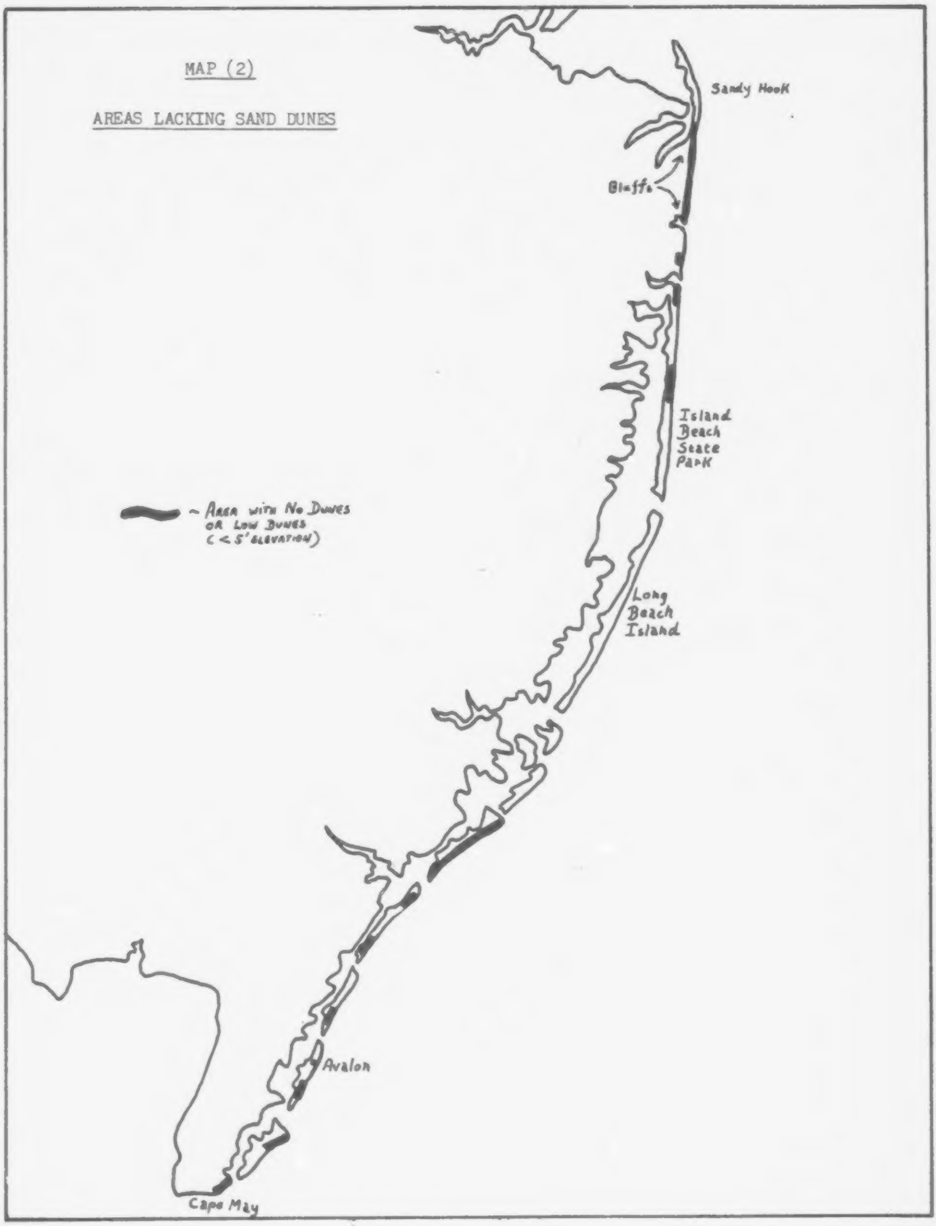
PROTECTIVE COASTAL SAND DUNES

On low lying coasts sand dunes provide natural barriers to storm surge flooding. They also retard shoreline recession by acting as sand reservoirs for eroding beaches. High and wide dunes offer the best protection to rearward human settlements.

The status of New Jersey's coastal dunes is assessed in a recent report by the Rutgers University Center for Coastal and Environmental Studies.[8] This shows that dunes are absent along much of Monmouth County, Absecon Island and Five Mile Beach (Wildwood) Island. While present elsewhere, they are discontinuous, low (i.e. less than 10 feet), and/or narrow (less than 150 feet), except at Sandy Hook, Island Beach State Park, Long Beach Island, Avalon and Cape May. (Map 2) Dunes rarely exceed 12 feet in elevation anywhere within the state. Only on Long Beach Island and at Avalon are relatively healthy dune systems present in association with populated areas.

AREAS OF CRITICAL EROSION

The New Jersey Shore Protection Master Plan (1980) classifies areas of critical erosion as places that experience significant damage in small to moderate storms.



MAP (2)

AREAS LACKING SAND DUNES

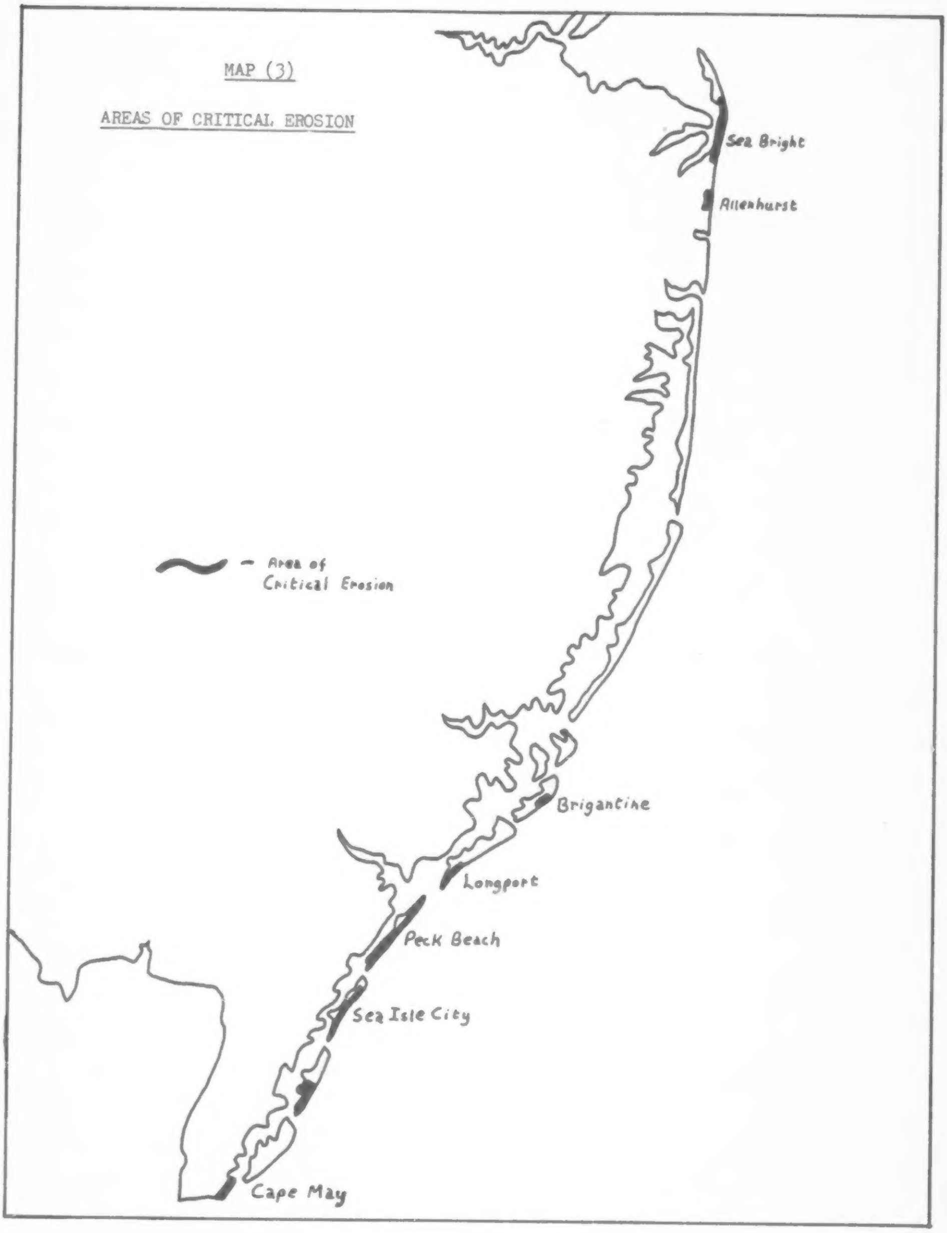
Sandy Hook
Bluffs
Island Beach State Park
Long Beach Island
Avalon
Cape May
~ Area with No Dunes or Low Dunes (< 5' elevation)

During severe storms these areas may undergo rapid large scale recession with consequent destruction of roads and facilities, perhaps involving the breaching of existing islands and the formation of new inlets.[9] With the exception of Sea Bright and the Elberon-Allenhurst portion of Monmouth County, areas of critical erosion are predominantly found south of Brigantine Inlet. (Map 3) There, particularly severe problems exist at the north end of Brigantine Borough, the southern tip of Absecon Island (Longport), the entire length of Peck Beach (Ocean City), most of Sea Isle City, Stone Harbor, and the eastern half of Cape May Borough.

COMPOSITE HAZARD SUSCEPTIBILITY

The preceding discussion of floods, dunes and erosion identifies the areal incidence of serious natural hazards. However, a complete analysis of hazard susceptibility requires the inclusion of information about storm probabilities because it is the storms that initiate serious flooding and accelerated erosion.

Two major types of storm affect the New Jersey coast: (1) noreasters; and (2) hurricanes. Each raises different problems for the evacuation of vulnerable areas. Noreasters are intense low pressure systems associated with meterological fronts. They occur mainly during winter months and generate relatively small surges that can persist throughout several high tide periods. Barrier islands are thus exposed to continuous and protracted wave attack that removes protective dunes, causes shoreline recessions and generates serious flooding. For example, the great March 1962 noreaster produced a 4.5 foot surge that lasted through 5 unusually high tide periods. It recorded a high water mark of 12.2 feet above (National Geodetic Vertical) datum on Absecon Island and flooded much of Atlantic City.[10] High water marks in excess of 11 feet were recorded throughout much of Atlantic and Cape May counties. Temporary inlets



MAP (3)

AREAS OF CRITICAL EROSION

- Area of Critical Erosion
Sea Bright
Allenhurst
Brigantine
Longport
Peck Beach
Sea Isle City
Cape May

were created at Harvey Cedars and Holgate (Long Beach Island) where high water marks of 6.1 feet and 7.2 feet respectively were reported.[11] This was the single most disastrous storm to affect coastal New Jersey during the last 80 years. It killed 14 people, injured 1,300 and destroyed or damaged 52,000 buildings.[12] Based on the historic record from 1921-1964, noreasters generate storm surges of 2 feet or more, five to six times a year at Atlantic City, and produce surges of over 4 feet approximately once every three years.[13] Hence, it is likely that New Jersey's barrier islands may require winter time evacuation in the face of severe noreasters. As recent coastal storms have shown,[14] winter conditions can create serious evacuation problems, although there are considerably fewer people at risk than during peak summer vacation periods.

In contrast to noreasters, hurricanes are infrequent but potentially more dangerous to human life. They generally occur in summer or early autumn between the months of May and October. However, in this century hurricanes have not inflicted serious loss of life on New Jersey's coastal communities. Adjacent locations such as Long Island (New York) have received direct hits by at least 7 hurricanes, including four Class 3 or greater storms. (i.e. winds 111-130 m.p.h.; surges 9-12 feet) Since 1900, hurricanes have affected New Jersey 5 times (1903, 1924,1944,1960,1976). The only direct hit was made by a relatively small and weak storm. (1903)

Based on the, admittedly limited, historic record, it is possible to divide the New Jersey shorefront into several hurricane risk zones. Much of the oceanfront between Long Beach Island and southern Cape May county has less than a 1% chance of experiencing a hurricane in any year. Southern Cape May county, southern Monmouth County and northern Ocean county have a slightly greater 1% chance of being affected by such a storm. Only in the northernmost section of Monmouth county (i.e. Sandy Hook) is there an appreciably greater (6%) chance of a hurricane striking the coast. This does not mean that major hurricanes will not occur; merely that they have no recent historical precedent.[15]

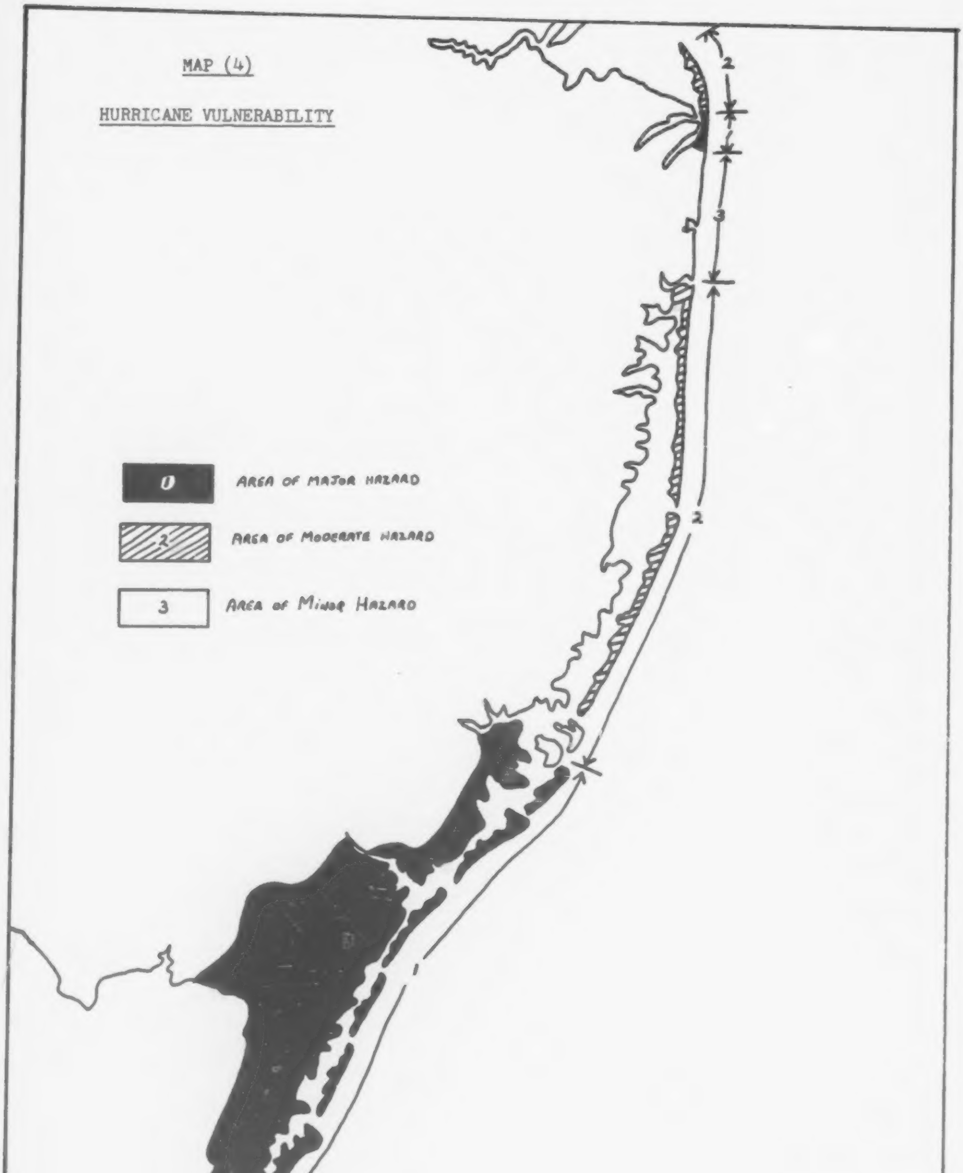
Taken together, the preceding data on floods, dunes, erosion and storms reveal a distinctive general pattern of hazard exposure. Due to its wide coastal flood plains, precarious erosion status, and discontinuous or absent dune systems, the southern half of the coastline, from Brigantine to Cape May, is most likely to experience hazard - generally as a result of noreaster storms. Despite a significantly greater risk of hurricanes along the northern portion of the state's oceanfront, exposure to hazard is much less than in the two southern counties. (i.e. Atlantic and Cape May) (Map 4)

POPULATIONS AT RISK

For the purposes of this report, populations at risk are defined as all occupants of municipalities located entirely on barrier islands and barrier beaches, or within Cape May county, together with pro-rated estimates of populations in municipalities that encompass both hazardous shorefront areas and secure mainland locations. Both permanent populations and temporary summer populations (i.e. vacation residents and day visitors) are at risk in such areas. Though they face similar hazards, the sizes and compositions of each group are distinctly different and both pose special problems for emergency planners.

THE UNOCCUPIED SHORE

Most of New Jersey's 124 mile long oceanfront is occupied by developed urban residential and recreational communities with permanent (year round) populations. However, 21.6% (26.8 miles) of the ocean frontage consists of publically owned



MAP (4)

HURRICANE VULNERABILITY

1
AREA OF MAJOR HAZARD
2
AREA OF MODERATE HAZARD
3
AREA OF MINOR HAZARD
2
3
2

lands dedicated to open space recreational and conservation uses. There are no permanent settlements in these places but most attract large numbers of summer visitors. The largest such entities are Island Beach State Park (9.9 miles); Brigantine National Wildlife Refuge and the adjacent North Brigantine State Natural Area (6.8 miles) and the Gateway National Recreation Area (Sandy Hook Unit) (6.1 miles). (Map 5) There is very little undeveloped ocean frontage (3.5 miles) on the coastal section south of Brigantine.

TABLE (1)

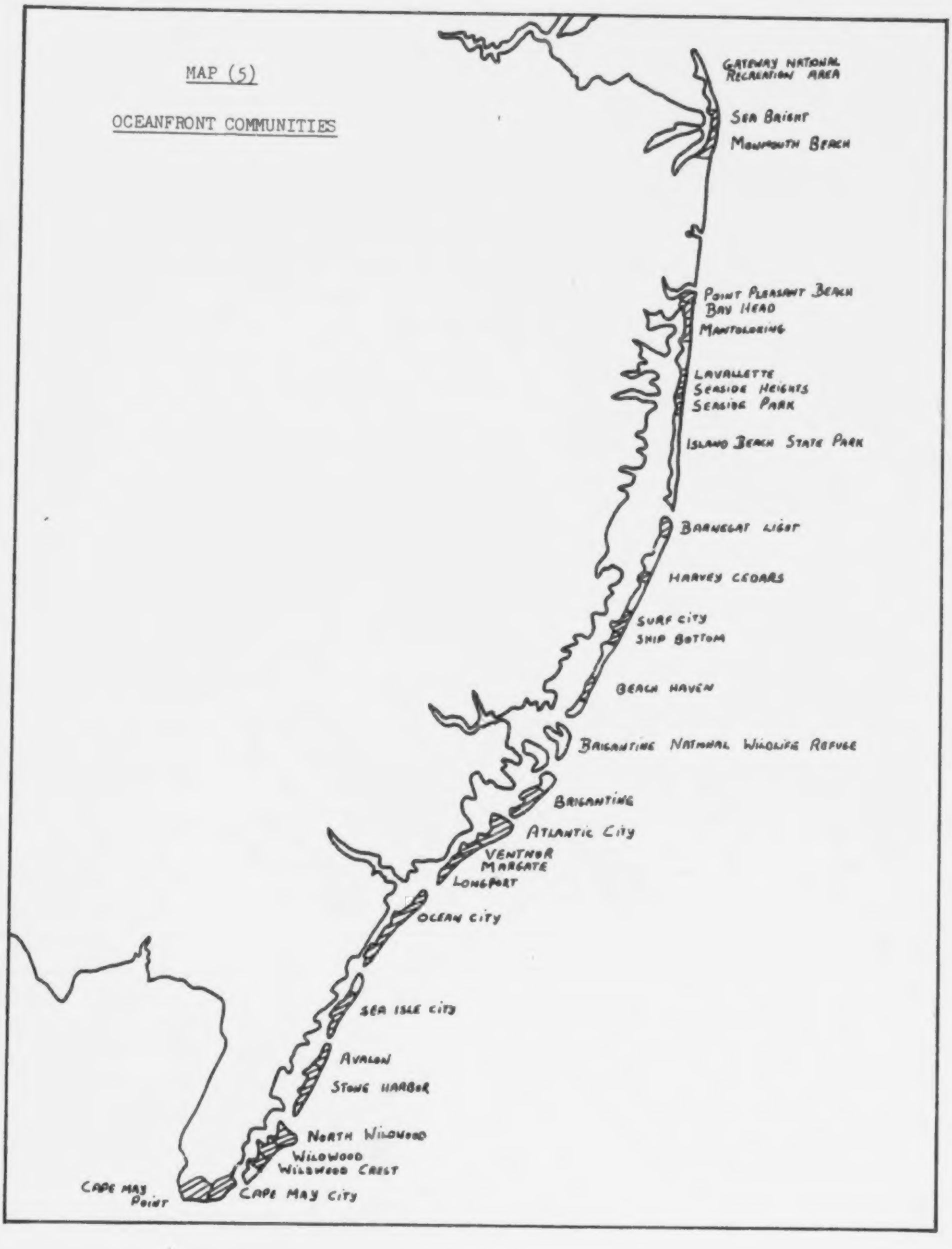
LAND DEDICATED TO OPEN SPACE OR LOW INTENSITY PUBLIC USES

Tract	Frontage (Feet)
Gateway National Recreation Area (Sandy Hook)	32,100
State Arsenal and Camp Ground (Sea Girt)	1,600
Island Beach State Park	52,300
Barnegat Light State Park	1,500
Brigantine National Wildlife Refuge (Holgate)	10,000
Brigantine National Wildlife Refuge (Pullan Island)	13,000
North Brigantine State Natural Area	13,000
Corson Inlet State Park	500
Strathmere Natural Area	800
U.S. Coast Guard - Wildwood	6,100
U.S. Coast Guard - Cape May	5,600
Cape May Point State Park	5,200
Total:	141,700 (21.6% of N.J. oceanfront land)

Source: N.J. Shore Protection Master Plan, 1980

PERMANENT POPULATIONS AT RISK

The hazardous developed shore includes several different types of community. One major urban center (Atlantic City), nine residential municipalities, and twenty three recreational resorts, with a total population of 185,984 are at risk. (Table 2) Moreover, population densities are more than three times greater than the New Jersey average (i.e. 940 per square mile), in this the nation's most densely populated state. Such congestion has the potential to hinder evacuation



MAP (5)

OCEANFRONT COMMUNITIES

Gateway National Recreation Area
Sea Bright
Monmouth Beach
Point Pleasant Beach
Bay Head
Mantoloking
Lavallette
Seaside Heights
Seaside Park
Island Beach State Park
Barnegat Light
Harvey Cedars
Surf City
Ship Bottom
Beach Haven
Brigantine National Wildlife Refuge
Brigantine
Atlantic City
Ventnor
Margate
Longport
Ocean City
Sea Isle City
Avalon
Stone Harbor
North Wildwood
Wildwood
Wildwood Crest
Cape May Point
Cape May City

However, close to two-thirds of the total live in somewhat lower density recreational communities which contain a high proportion of seasonal rental structures and tourist services. (Table 3) Ninety seven percent (97.2%) of the permanently resident population at risk reside in Ocean, Atlantic and Cape May counties.

TABLE (2)

PERMANENT POPULATIONS AT RISK (by county)

County	Total Population	Oceanfront Municipalities	At risk coastal Population	% at risk
Monmouth	503,173	107,650	5,130	2.8
Ocean	346,038	28,039	27,939	15.0
Atlantic	194,119	70,649	70,649	38.0
Cape May	82,266	38,826	82,266	44.2
Totals	1,125,596	205,164	185,984	100.0

Source: U.S. Census of Population, 1980

MONMOUTH COUNTY

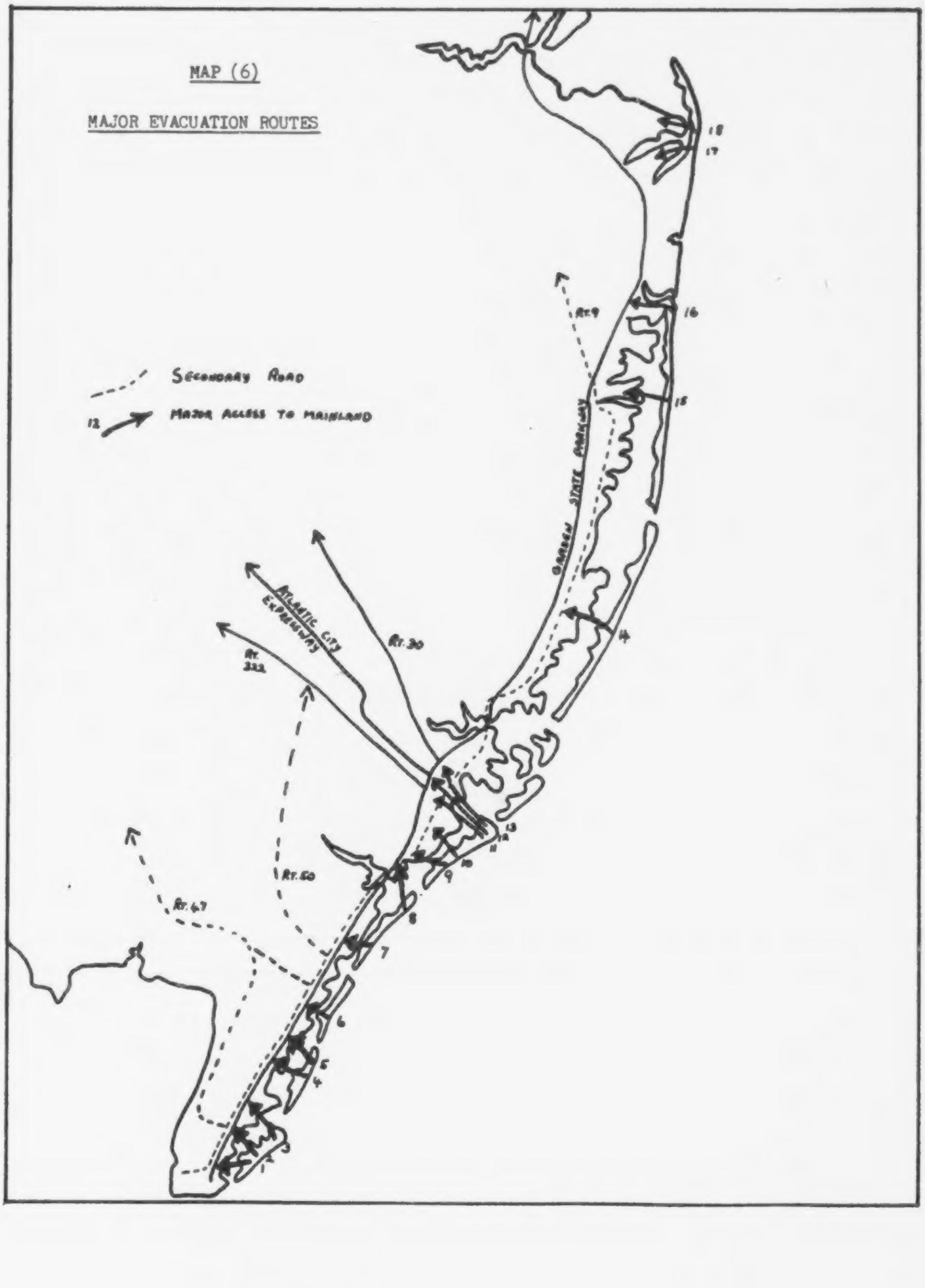
With the exception of a short barrier beach segment containing Sea Bright and Monmouth Beach, most of Monmouth's oceanfront communities are located on relatively secure mainland bluffs with easy access to the rest of the state via a dense network of transportation routes. Just over 5,000 permanent residents are at risk in Monmouth county.

OCEAN COUNTY

Vulnerable populations reside in two contrasting areas. The Oyster Creek nuclear power station lies five miles east of the ocean, on the mainland, midway between both areas. (a) A chain of small communities lines the peninsula that stretches from Point Pleasant Beach to Island Beach State Park. Much of this district has direct access to the mainland at Point Pleasant and two relatively short causeway/bridges serve the remaining communities. Here the permanent population at risk is approximately 18,900. (b) Further south lies Long Beach Island - the first of New Jersey's true barrier islands. A single bridge crosses five miles of open water and wetlands to connect the mid section of the 21 mile island with the mainland. Close to 17,700 permanent residents are at risk on Long Beach Island. The elderly nature of this population raises problems for evacuation managers. Its median age is more than 45 years (1981) - considerably beyond that of most oceanfront areas. (Map 6) Illnesses and physical handicaps that sometimes accompany the process of aging, require special provisions in evacuation planning.

ATLANTIC COUNTY

Atlantic county contains the state's only entirely undeveloped barrier island (Pullan Island in Brigantine National Wildlife Refuge), and its most continuously urbanized shorefront. Eight mile long Absecon Island is occupied by the boardwalks, highrise apartment blocks, casinos and heavily used beaches of Atlantic City, Ventnor, Margate and Longport. It is separated from the mainland by a five mile strip of bay waters and wetlands. The four municipalities are served by at least 5 major highway links to the mainland, as well as an airport and a linear coastal highway crossing Great Egg Harbor Inlet. A railroad line formerly connected Atlantic City to the Camden-Philadelphia area, and there have been recent proposals to reopen this connection. Nine mile long Brigantine Island is lightly populated but residents must drive to the mainland via a circuitious route through Atlantic City. Over 70,000 permanent residents are at risk in Atlantic county.



MAP (6)

MAJOR EVACUATION ROUTES

Secondary Road
12 Major Access to Mainland
Rt.9
Garden State Parkway
Atlantic City Expressway
Rt.30
Rt. 322
Rt.50
Rt.47
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

CAPE MAY COUNTY

The single largest permanent population at risk is located in Cape May county. Although the barrier islands account for only 47% of the total population, virtually all of Cape May county's 82,266 people live in areas subject to inundation by major storm surges. However, the barrier islands are particularly susceptible to hazard. Four islands, ranging in length from 6.1 to 8.4 miles, are separated from the mainland by a belt of wetlands and bays up to 12 miles wide. Eight bridges and causeways traverse these low-lying areas and feed traffic to three flood-prone highways that link Cape May county with Cumberland and Atlantic counties.

TOTAL PERMANENT POPULATION

In summary, approximately 186,000 people maintain permanent homes on the barrier islands, barrier beaches and flood-prone mainland of New Jersey's oceanfront coast. Almost 45% of this number are located in Cape May county. This is also the most physically exposed, hazardous region and the one most lacking in adequate transportation routes for rapid evacuation of threatened occupants. Another 38% of the total population at risk resides in Atlantic county. Most are found within the compact confines of Absecon Island, close to highrise buildings that may provide a limited capacity for "vertical evacuation".[16] This area also possesses substantial transportation links with the mainland. Fifteen percent of the population at risk are located in Ocean county. Half of these are relatively well served by evacuation routes and facilities in the northern portion of the county. The remainder occupy highly exposed Long Beach Island. The latter groups possess only one travel route to the mainland. Finally, only a small fragment of Monmouth county's oceanfront population occupies hazardous locations that may require evacuation.

FUTURE POPULATIONS

Population projections by the New Jersey Department of Labor and Industry suggest that, over the next 20 years, the populations of Atlantic, Ocean and Cape May counties will increase by between 60% and 100%.[17] Permanent populations at risk in coastal areas seem likely to grow at a much slower pace than surrounding counties. This is a consequence of existing congestion, deed restrictions, state controls on construction, federal flood insurance provisions and local zoning regulations. Nonetheless, there is a potential for "infilling" of existing communities and some growth of population may occur. Even a conservative increase of 10% to 20% before the year 2000, could produce a total permanent population at risk of between 205,000 and 223,000. Most of the additional growth would probably occur in Cape May county - the area of greatest hazard.

SEASONAL POPULATIONS AT RISK

Seasonal populations include overnight visitors and day visitors.

OVERNIGHT VISITORS

Large numbers of people spend their annual summer vacations at the Jersey Shore. Most patronize a single resort and are unfamiliar with the broader coastal region. They may also be relatively uninformed about the character of coastal hazards. Some stay for periods in excess of one month; others for a week or less. It is generally known that a great variety of household units are represented in this population. They include nuclear families vacationing together, families where heads of households commute to join spouses and children at weekends, young singles, retired couples, French speaking visitors from Quebec Province and many others. A majority are believed to bring their own transportation but others either lack cars during some periods or use public transportation. Numbers of vacationers who have no regular access to television, radio or newspapers are unknown but thought to be significant. Inasmuch as locally knowledgeable people, readily available communications and adequate transportation are keys to successful warning and evacuation programs, there is reason to be more concerned about the hazard susceptibility of summer vacationers than permanent residents.

DAY VISITORS

The New Jersey shore attracts large numbers of visitors who return home each night. Day visitors are especially important to Atlantic City. For example, more than 250,000 special buses arrived at Atlantic City casinos between January 1 and October 31, 1982.[18] The mayor of Atlantic City recently announced (6/12/83) that up to 2,000 buses enter the city on some days. Other communities that are known to attract significant numbers of day visitors include Ocean City, Seaside Heights, Long Beach Island, the Wildwoods and Sea Isle City.

Day visitors pose somewhat different evacuation problems than overnight visitors. From one perspective, day visitors may be less at risk. Some may choose not to visit shore areas on days when storms are forecast. Many are likely to depart shore communities by nightfall and, therefore, to be unaffected by storms that make landfall between sunrise and noon of the following day. Day visitors may also have less incentive than overnight visitors to remain, after storm warnings are issued. Conversely, day visitors comprise the single largest group of seasonal visitors in many of the larger communities. Many, especially the poor and the elderly, arrive in buses. Special provisions must be made to ensure that sufficient public transportation is available on short notice to remove them to safety, and that supporting medical and food services are on hand. However, it is unlikely that casinos and other shore businesses will encourage their patrons to leave in the face of threatening storms.

SEASONAL POPULATION DATA

There is no systematic record of seasonal population data for New Jersey. This absence seriously hampers any study of coastal storm evacuation. Of necessity, the investigator must rely on various estimates of summer population that may be subject to significant error.

Two main sets of estimates of seasonal population are available. (1) Seasonal population ratios (i.e. summer population/ permanent population). These have been calculated for coastal communities, by Dames and Moore, consultants for the New Jersey Shore Protection Master Plan.[19] They include all coastal communities considered in the present study except those on Absecon Island. (2) The Philadelphia-based consulting firm of Rogers, Golden and Halpern has also produced an"Inventory of Visitors in Shorefront Municipalities"for a recent coastal recreation study.[20] This includes separate data on seasonal home residents, hotel and motel visitors, visiting friends and relatives, campground occupants, and day parties. It is based, in turn, on survey data from the Rutgers Poll (Eagleton Institute); information provided by municipal clerks; tourist and visitor bureaus, and other sources. It is possible to convert the annual visitor day totals supplied in the Rogers, Golden and Halpern study to peak day visitor attendance in each community by employing a conversion equation that includes permanent population, information on average length of stays, traffic counts and other data. (Appendix I)

Table (3) shows permanent (winter) populations at risk (Col.1), and two sets of estimates for summer populations at risk (Cols. 2 and 3). Column 2 is based on Dames and Moore's information and Column 3 is based on the Rogers, Golden and Halpern study. Both Columns 2 and 3 include permanent populations. Where information on attendance at large state or federal parks is known, it is also provided.

It is readily apparent that figures in Column 2 (hereafter known as the "high peak population estimate") are two to eight times greater than figures in Column 3 ("low peak population estimate"). These differences stem from different assumptions used in the two source studies and from different accounting procedures. In all probability neither set of data is entirely correct, but it is assumed that - taken together - both will ususally bracket the true totals. For example, it has been separately estimated that Long Beach Island contained 64,000 people on August 6, 1976 - a near peak summer population date.[21] More recently, other observers have suggested that up to 100,000 people may be present on a peak day. The Dames and Moore seasonal population ratio indicates that 122,215 people may be present at such times, whereas the Rogers, Golden and Halpern data suggest 30,214. In this case, the likely population may lie midway between the two sets of data used in this study. However, it is possible that Table (3) may seriously underestimate actual peak populations for some communities. Cape May

County is often reported to contain up to 1 million people on a peak summer weekend. That is 69% more people than estimated in the "high peak population estimate" used in this analysis.(i.e. 592,539) During holiday peak periods, evacuation managers might do well to err on the side of caution and plan for larger numbers than shown in Column 2 of Table (3).

Table (3) suggests that the total population at risk during peak summer periods lies between 0.75 and 1.75 million. Absecon Island heads the list of localities that possess the largest numbers of potential evacuees (391,510-776,083). It outranks, respectively, Cape May County (189,819-592,539); mid-Ocean County (i.e. Lavallette to Island Beach State Park) (91,363-178,953); Long Beach Island (30,214-122,215); northern Ocean County (18,339-56,388); and Monmouth County (26,057-29,749).

TABLE (3)

POPULATIONS AT RISK

Communities at risk*	Permanent Population (1980)	High Peak Population Estimate	Low Peak Population Estimate
Gateway National Recreation Area	0**	20,000***	20,000
Sea Bright Borough	1,812	5,436	2,245
Monmouth Beach Borough	3,318	4,313	3,812
Point Pleasant Beach	5,415	38,447	8,407
Bay Head Borough	1,240	7,370	2,154
Mantoloking Borough	433	2,771	865
Brick,Dover and Berkeley Townships (parts)	6,000	7,800	6,913
Lavallette Borough	2,072	29,422	5,543
Seaside Heights Borough	1,802	46,131	13,806
Seaside Park Borough	1,795	35,900	4,515
Island Beach State Park	0**	67,500****	67,500
Barnegat Light Borough	619	8,976	1,981
Harvey Cedars Borough	363	5,082	1,990
Surf City Borough	1,571	14,767	4,353
Ship Bottom Borough	1,427	19,122	3,516
Long Beach Township	3,488	42,902	13,799
Beach Haven Borough	1,714	31,366	4,575
Brigantine City	8,318	22,445	14,691
Atlantic City	40,199	683,596*****	341,798
Ventnor City	11,704	34,050*****	17,025
Margate City	9,179	29,830*****	14,915
Longport Borough	1,249	6,162*****	3,081
Ocean City	13,949	136,700	34,631
Upper Township (part)	500	1,500	3,708
Sea Isle City	2,644	24,060	9,371
Avalon Borough	2,162	14,431	8,895
Stone Harbor Borough	1,187	17,449	6,282

(continued)

(continued from p.22)

Communities at risk	Permanent Population (1980)	High Peak Population Estimate	Low Peak Population Estimate
North Wildwood City	4,714	70,710	17,655
Wildwood City	4,913	98,260	17,848
Wildwood Crest Borough	4,149	47,299	17,082
Cape May City	4,853	28,633	12,984
Cape May Point Borough	255	3,137	822
SUBTOTALS******	142,044	1,605,567	686,762
Non-oceanfront areas of Cape May County at risk	42,940	150,360	60,541
TOTALS	185,984	1,755,927	747,303

*Some small pieces of public land not included

** Small permanent and overnight populations ignored

*** U.S. Dept. of the Interior, National Park Service, Gateway National Recreation Area: Environmental Impact Statement, (197), p.

**** New Jersey, Department of Environmental Protection, Shore Protection Master Plan, 1980.

***** Estimated populations double "low peak population estimate"

****** Does not include Borough of West Wildwood (perm. pop. 360) and other small communities not separated from Cape May County township data in Dames and Moore study (i.e. high peak population estimate) or Rogers, Golden, Halpern study (i.e. low peak population estimate). These communities are included in Table (3) under "Non-oceanfront areas of Cape May County at risk."

EVACUATION

Evacuation is the process by which threatened populations seek safety outside areas at risk. Although individuals may make private decisions, as the term "evacuation" is used here, it refers to the organized public, community-wide movement of people that follows a formal evacuation message.

The barrier island and lowlying mainland coasts of New Jersey are seriously at risk to storm surge inundation and, few, if any, of their buildings can be relied on to guarantee the safety of coastal occupants. It may be technically possible to shelter some evacuees in upper storeys of high rise buildings on Absecon Island and elsewhere, but this so-called "vertical evacuation" is an unpopular alternative among owners of highrise buildings - other than casinos - and among local officials and private citizens. Thus, evacuation of all threatened populations to safe mainland shelters is the preferred choice for emergency managers.

ROUTES, CAPACITIES AND EVACUATION TIMES

Evacuation is, first and foremost, a time sensitive process. Its success depends on the ability of people to organize for, undertake and complete journeys to safety before the arrival of dangerous winds, waves or other life-threatening conditions. Thus knowledge of projected evacuation times is essential to the formulation of emergency management plans.

The length of time required to complete an evacuation journey is composed of two main elements: (1) reaction time after an evacuation message has been broadcast, during which the message is disseminated among a target population, evaluated, responses decided on and family members or other groups assembled; (2) travel time necessary to cover the distance to a safe location.

It is difficult to develop highly accurate estimates of each time element in advance of a specific emergency. For example, reaction time may, or may not, be reduced by the priming effect of pre-evacuation warnings. Local government leaders generally authorize evacuations after receipt of hurricane warnings issued by the National Weather Service. However, an evacuation message is not necessarily preceded by a hurricane watch or warning. Moreover, a storm evacuation message may be transmitted as an advisory or as an order. Although residents are not legally bound to comply, an order may be perceived as more authoritative and urgent, thereby stimulating increased response. In addition, the decision to evacuate involves a wide range of behavioral, informational and material factors that vary among individuals and family groups.[22]

Travel time is similarly difficult to estimate, although for different reasons. It involves both movement time and delay time. Movement time can easily be calculated by dividing travel distance by average speed. However, delay time is a function of the numbers and types of evacuation vehicles; highway capacity; patterns of bottlenecks and intersecting travel flows; vehicle breakdowns and accidents; highway and weather conditions; competition for road space among evacuees and emergency vehicles; safe shelter search behavior; and a variety of other factors.

Previous research has shown that up to 30% of a barrier island's population may leave before a formal evacuation order is issued.[23] Perhaps 10% -20% may not attempt to leave at any time. Most of the remainder generally leave in a 5 to 6 hour period immediately following an evacuation order. Yet these figures may be misleading because they reflect the experience of Gulf Coast communities with relatively small populations and disproportionately fewer seasonal residents and summer day visitors than Northeastern resorts.

The length and difficulty of an evacuation journey varies widely among New Jersey communities. In some places it involves a transit of less than a mile across a narrow neck of water to high ground in a mainland community well supplied with potential shelters and an extensive transportation network capable of speeding the journey inland. Elsewhere, it entails crossing five or six miles of barrier island, wetlands and lagoons to a lowlying mainland, followed by an additional lengthy trip before reaching high ground in sparsely populated municipalities that lack adequate public shelters.

Other things being equal, evacuees who must complete longer journeys, composed of more segments, are more likely to experience difficulties than are those who follow shorter and simpler routes. In general, evacuation journeys are shorter and less complex in Monmouth, Ocean and Atlantic counties. There, only in parts of Long Beach Island and Brigantine do the distances exceed 10 road miles. Only in Brigantine is it necessary to cross more than one major bridge or causeway to reach safe mainland locations. By contrast, journeys of 20 to 35 miles, often involving several bridge and causeway crossings, are typical in Cape May county.

For the purposes of this analysis the following assumptions have been made: (1) populations at risk are as shown in Table (3); (2) all evacuation is carried out by road; (3) no persons remain in communities at risk after evacuation is complete; (4) evacuation vehicles carry an average of 4 passangers; (5) two lane evacuation routes carry only outbound traffic while one land of four lane routes remains open for inbound and emergency vehicles; (6) there is a uniform reaction of 1.0 hour in all communities at risk; (7) non-delayed travel time to safe locations varies from 0.5 hours (Gateway National Recreation Area to Island Beach State Park), to 1.0 hours (Long Beach Island to Absecon Island), to 2.0 hours (Cape May County); and (8) evacuees follow optimal routing and scheduling plans.

Evacuation times are calculated for two levels, and three variables: (1) population scenarios: (a) high peak population estimate; (b) low peak population estimate; (2) traffic volumes: (a) 30th peak hour volume (i.e. typical rush hour traffic on a normal summer day); (b) highway design capacity (See Appendix I); and (3) evacuation areas: (a) local (i.e. barrier islands and exposed oceanfront locations only); and (b) general (i.e. all lowlying coastal areas at risk including mainland Cape May County). All bridges, causeways and highways linking barrier islands with adjacent mainland areas are included in the analysis together with Cape May County's five exit highways. Ranges of evacuation times are tabulated in summary form for local and general evacuation areas.

LOCAL EVACUATION

Table (4) illustrates time required for (1) high peak populations, and (2) low peak populations to leave hazardous oceanfront areas for safe mainland locations at (a) 30th peak hour, and (b) highway design capacity traffic volumes. (See Appendix III for sample calculation)

From Table (4) it can be seen that some communities at risk may be evacuated quickly. For example, it is unlikely that more than 4 hours would be required to evacuate threatened Monmouth County shorefront communities. By contrast, it may take more than 16 hours to totally evacuate Absecon Island or the Wildwoods during peak summer occupance periods. Even under the optimistic "low peak population estimate", between 7 and 9 hours will be required to complete an evacuation of Absecon Island.

GENERAL EVACUATION

Estimates shown in Table (4) seriously underrepresent the amount of time necessary to evacuate Cape May County. A further calculation is necessary for the southern portion of the New Jersey Shore because virtually all of that area is seriously at risk to storm flooding.

Without constructing a mathematical transportation model, it is difficult to state what might be an optimal evacuation schedule and routing program for all of Cape May County. However, it is possible to gain some idea of possible aggregate evacuation times from the following example. Figure (1) illustrates calculated 30th peak hour traffic volumes on major evacuation routes from barrier islands to the mainland and out of Cape May County. Evacuation proceeds under the following assumptions:

(1) Garden State Parkway and Route 9 are dedicated priority evacuation routes for barrier island populations;

(2) State Routes 50 and 550 function only to distribute traffic from the northern sectors of the Garden State Parkway and Route 9

TABLE (4)

LOCAL EVACUATION TIMES*

COMMUNITY	HIGH PEAK POPULATION ESTIMATE			LOW PEAK POPULATION ESTIMATE		
	N	30th Peak Hour	Capacity	N	30th Peak Hour	Capacity
Gateway N.R.A.	20,000	3.7	2.5	10,000	2.6	2.0
Sea Bright	5,436	3.6	3.0	2,245	2.4	2.1
Monmouth Beach	4,313	1.8	1.6	3,812	1.7	1.6
N. Ocean County	56,388	5.9	?	48,379	5.3	?
Mid Ocean County	178,953	9.0	6.7	91,363	5.3	4.2
Long Beach Island	122,215	9.3	7.9	30,214	3.8	3.5
Absecon Island	783,020	16.4	12.4	381,510	9.0	7.1
Ocean City	136,700	14.0	10.4	34,631	5.0	4.1
Strathmere - Sea Isle City	25,560	13.3	6.2	13.079	7.8	4.2
Stone Harbor - Avalon	31,880	8.7	4.9	15,177	5.2	3.4
Wildwoods	216,269	16.9	11.9	52,585	5.6	4.4

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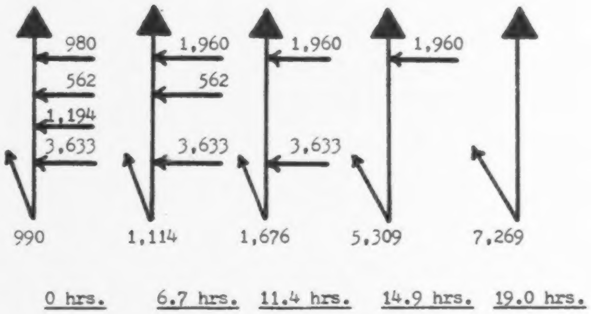
*Evacuation times in hours (cols. 3,4,6,7). Includes 1 hour reaction time; time to complete departure of all evacuees (variable); and time required to arrive at safe destination (i.e. 0.5 hours - Gateway N.R.A. to Mid Ocean County; and 1.0 hours - Long Beach Island to Cape May). Does NOT take into account road closures due to high winds and rising water in advance of the storm.

FIGURE (1)

GENERAL EVACUATION OF CAPE MAY COUNTY (30th PEAK HOUR TRAFFIC VOLUME)

COMMUNITY	POPULATION REMAINING AFTER 0 hrs.	6.7 hrs.	11.4 hrs.	14.9 hrs.	19.0 hrs.	19.7 hrs.
Ocean City	136,700	110,436	83,139	32,065	0	0
Strathmere-Sea Isle City	25,560	10,498	0	0	0	0
Avalon-Stone Harbor	31,880	0	0	0	0	0
Wildwoods	216,269	118,905	50,605	0	0	0
Mainland Cape May County	182,130	155,598	125,655	106,516	19,448	0


980
562
1,194
3,633
990
1,960
562
3,633
1,114
1,960
3,633
1,676
1,960
5,309
7,269
0 hrs.
6.7 hrs.
11.4 hrs.
14.9 hrs.
19.0 hrs.

SCHEMATIC REPRESENTATION OF TRAFFIC VOLUMES FOR TABLE ABOVE* to safe areas in Atlantic and Cumberland counties;

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*Volume in numbers of vehicles per hour; 30th peak hour; high peak population estimate.

(3) The more southerly barrier island communities take precedence over the more northerly barrier island communities in the use of Route 9 and the Garden State Parkway;

(4) Route 47 is dedicated exclusively for evacuation of mainland populations;

(5) A maximum of 2 hours is required to complete the longest evacuation journey in Cape May County.

Table (5) summarizes general evacuation times for the county. A general evacuation of Cape May County will be somewhat slower than a local evacuation of barrier islands. For some communities, perhaps 8 hours may be added to the process. However, there are striking differences in the ranking of evacuation problem areas depending on which peak population estimates and which traffic flow data are used. (Table 6) Nonetheless, Atlantic and Cape May counties clearly lead the list of evacuation problem areas.

EVACUATION TIMES: A REASSESSMENT

Evacuation times derived via the preceding analysis must be treated as approximations. They are based on assumptions that may not be realized in practice. Nevertheless, they represent the best range of estimates currently available.

To the extent that actual conditions diverge from assumptions used here, total evacuation times may be increased or reduced. For example, in the Wildwoods, if it is assumed that: (a) accidents and breakdowns reduce traffic flows to 2/3's of the 30th peak hour volume; and (b) vehicles carry an average of 3 persons, then approximately 32.8 hours will elapse before all occupants of this community have left Cape May County. This is almost twice as long as the "general" evacuation time (17.9 hours) noted in Table (5). Conversely, if

TABLE (5)

GENERAL EVACUATION TIMES*

COMMUNITY	HIGH PEAK POPULATION ESTIMATE			LOW PEAK POPULATION ESTIMATE		
	N	30th Peak Hour	Capacity	N	30th Peak Hour	Capacity
Gateway N.R.A.	20,000	3.7	2.5	10,000	2.6	2.0
Sea Bright	5,436	3.6	3.0	2,245	2.4	2.1
Monmouth Beach	4,313	1.8	1.6	3,812	1.7	1.6
N. Ocean County	56,388	5.9	?	48,379	5.3	?
Mid Ocean County	178,953	9.0	6.7	91,363	5.3	4.2
Long Beach Island	122,215	9.3	7.9	30,214	3.8	3.5
Absecon Island	783,020	16.4	12.4	381,510	9.0	7.1
Ocean City	136,700	22.0	14.2	34,631	7.4	5.9
Strathmere-Sea Isle City	25,560	14.4	7.2	13,079	8.8	5.2
Stone Harbor-Avalon	31,880	9.7	5.8	15,177	6.2	4.3
Wildwoods	216,269	17.9	12.9	52,585	6.6	5.4
Mainland Cape May County	182,130	22.7	13.6	74,347	9.0	6.4

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* Table (5) is similar to Table (4) for all communities other than those in Cape May County. Times (in hours) reported in Cols. 3,4,6 and 7 are made up of three components: (i) uniform reaction time - 1 hour; (ii) time to complete departure of all evacuees (variable); and (iii) time to arrive at safe destinations calculated as follows - 0.5 hours, Gateway N.R.A. to Mid Ocean County; 1.0 hours, Long Beach Island to Absecon Island; 2.0 hours, Cape May County. NOTE: Mainland Cape May includes Cape May City and Cape May Point Borough. The table DOES NOT take into account road closures due to high winds and rising water in advance of a storm.

TABLE (6)

RANKED EVACUATION PROBLEM AREAS (GENERAL EVACUATION)*

COASTAL SEGMENT	HIGH PEAK POPULATION ESTIMATE		LOW PEAK POPULATION ESTIMATE	
	30th Peak Hour	Capacity	30th Peak Hour	Capacity
Gateway N.R.A.	10	10	10	10
Sea Bright	11	9	11	9
Monmouth Beach	12	11	12	11
N. Ocean County	9	?	7.5	?
Mid Ocean County	8	7	7.5	7
Long Beach Island	7	5	9	8
Absecon Island	4	4	1.5	1
Ocean City	2	1	4	3
Strathmere-Sea Isle City	5	6	3	5
Stone Harbor-Avalon	6	8	6	6
Wildwoods	3	3	5	4
Mainland Cape May County	1	2	1.5	2

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* 1 = most serious problem; 12 = least serious problem.

it is assumed that: (a) 20% of the target population will not attempt to leave; (b) no day parties are permitted entry; (c) evacuation occurs at route design capacities; (d) vehicles carry 5 passengers; and (e) all evacuation route lanes are reserved for outbound traffic, occupants of the Wildwoods could be evacuated from Cape May County in just under 4 hours (3.75 hours). (This example assumes that there are no other changes from the "general" evacuation scenario elsewhere in Cape May County.) Therefore, depending on the assumptions used, a total evacuation of the Wildwoods could take as few as 4 hours or as many as 33 hours. Hence, the values noted in Table (4) and Table (5) should be used only as a guide to relative evacuation times, not as precise predictions.

COMPARISON OF CALCULATED AND ACTUAL EVACUATION TIMES

It is important to remember that few coastal storm related evacuations in New Jersey have been documented and analyzed in detail. An exception is the August 9, 1976 evacuation of Long Beach Island in advance of the approaching hurricane Belle.[24] Approximately 64,000 people were estimated to be on the island at the outset. This is approximately midway between the "low peak population estimate" (i.e. 30,214) and the "high peak population estimate" (i.e. 122,215) used in this study.

Between 5% and 10% of the population did not leave despite the existence of a "mandatory" evacuation order. The remaining 57,600 to 60,800 left over an estimated 10 hour period. This compares with estimates in this study of 3.5 to 3.8 hours (low peak population estimate) and 7.9 to 9.3 hours (high peak population estimate). Thus the actual evacuation took longer than calculated here. Much of the difference can be explained by the fact that the evacuation rate of 2,000 vehicles per hour was less than half that of the 30th peak hour volume.

This is at least partly attributable to toll booth delays at the entrance to the Garden State Parkway. In the future such delays may be prevented by new emergency procedures adopted since 1976. Nonetheless, if the Long Beach Island experience is typical, it may be necessary to allow considerably more time than reported in this study, for the evacuation of all people at risk on the New Jersey oceanfront.

Several thousand people were evacuated from coastal communities in Monmouth County on March 29, 1984 during a strong noreaster. Between 1,000 and 2,000 of these were permanent residents from Sea Bright and Monmouth Beach. Evacuations began around 9 a.m. and were completed by noon or shortly thereafter. Thus, a winter evacuation that removed less than the entire coastal population at risk required as much, or more, time than is projected in this study for total removal of larger summer populations. (Table 5) Moreover, although the initial reports of threatening conditions were received by State Police around 5 a.m. on March 29, the Governor did not declare a limited state of emergency for Monmouth County communities until 8.10 a.m. Thus, three hours elapsed between the onset of danger and public decisions that led to evacuations. This again suggests the need for regarding evacuation estimates contained herein as minimum theoretical evacuation times that are likely to be exceeded in reality.

IS THERE ENOUGH TIME?

A successful evacuation is one that removes to safety, all people at risk, before the onset of dangerous conditions. Can New Jersey's coastal storm threatened populations be successfully evacuated in advance of a hurricane? Based on the analyses carried out so far, the prospects are not encouraging.

Most coastal communities in New Jersey rely, directly or indirectly, on the National Weather Service for information about developing hurricanes and other storms.[25] Hurricane Watches are issued by the National Hurricane Center in Miami, 36 hours in advance of expected landfalls and Hurricane Warnings are issued 24 hours before impact is expected. However, there is no guarantee that a 24 hour Warning will be issued for a New Jersey hurricane. Neil Frank, Director of the National Hurricane Center has recently pointed out that hurricanes which move up the east coast of the United States can accelerate quickly, attaining forward speeds of 50 m.p.h., and thereby reducing warning times to perhaps 6,8 or 12 hours.[26] He cautions against relying on the availability of a 24 hour warning period in Northeastern states.

Table (7) displays the range of evacuation problem communities in New Jersey, for three warning periods (24 hours, 12 hours, 6 hours) and the eight scenarios used in this study. It is based on the evacuation times generated in Tables (4) and (5), plus an additional 5 hour period necessary to take account of highway closures due to flooding, wind and rain and to provide for decision making delays before an evacuation advisory is issued in local communities.*

This table suggests that local evacuations of all communities at risk can be completed within the "normal" 24 hour hurricane Warning period. However, a general evacuation of Cape May County would not be possible within 24 hours under one scenario (i.e. high peak population estimate; 30th peak hour traffic flow). In short, there may be localized problems and "close calls" but most populations at risk are likely to reach safety if they receive 24 hours warning and respond optimally,following the assumptions used in this study.

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* Lowlying escape routes are likely to be blocked by rising water for 3 to 5 hours before the hurricane's "eye" makes landfall.[27] Likewise, such routes may be rendered impassable by high winds and heavy rain up to 6 hours prior to landfall.[28] As occurred in March 1984, it may require several hours between the detection of threatening conditions (i.e. Warning) and the issuance of local evacuation messages.

TABLE (7)

WARNING TIMES AND UNSUCCESSFUL EVACUATIONS

SCENARIO	WARNING PERIOD 24 HOURS	12 HOURS	6 HOURS
Local Evacuation			
(a) low peak population estimate			
(1) 30th peak hour	NONE*	Absecon Island Strathmere-Sea Isle City	ALL*
(2) capacity	NONE	Absecon Island	ALL
(b) high peak population estimate			
(1) 30th peak hour	NONE	Mid Ocean County Long Beach Island Absecon Island Ocean City Strathmere-Sea Isle City Stone Harbor-Avalon Wildwoods	ALL
(2) capacity	NONE	Long Beach Island Absecon Island Ocean City Wildwoods	ALL
General Evacuation			
(a) low peak population estimate			
(1) 30th peak hour	NONE	Absecon Island Ocean City Strathmere-Sea Isle City Mainland Cape May County	ALL
(2) capacity	NONE	Absecon Island	ALL

(continued)

(continued from p.37)

	WARNING PERIOD		
SCENARIO	24 HOURS	12 HOURS	6 HOURS
(b) high peak population estimate			
(1) 30th peak hour	Ocean City Mainland Cape May County	Mid Ocean County Long Beach Island Absecon Island Ocean City Strathmere-Sea Isle City Stone Harbor-Avalon Wildwoods Mainland Cape May County	ALL
(2) capacity	NONE	Long Beach Island Absecon Island Ocean City Strathmere-Sea Isle City Wildwoods Mainland Cape May County	ALL

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* NONE = no unsuccessful evacuations; ALL = all evacuations unsuccessful throughout coastal communities at risk.

If the warning period is significantly less than 24 hours major problems begin to occur. With 12 hours warning some communities cannot be evacuated in all scenarios (e.g. Absecon Island). In four or more scenarios complete evacuations fail to occur in Atlantic County, most of Cape May County and on Long Beach Island. With only 6 hours warning no communities at risk can be successfully evacuated on the New Jersey shore.

Clearly, the strong possibility that 12 hours warning or less may be all that is available in the event of a hurricane menacing New Jersey,places the safety of many coastal residents in jeopardy. That this is not an understatement of the risks becomes clear when behavioral information about likely population responses to emergencies is taken into account.

BEHAVIORAL INFLUENCES ON EVACUATION

The basic assumptions about human behavior that underlie most public evacuation studies are those of rationality and freedom of action. In other words, it is assumed that people at risk recognize the risks, know what to do about them, are willing to practice appropriate measures, and are not prevented from so doing. To test these assumptions, a questionnaire survey was mailed to 313, randomly chosen, permanent residents of coastal communities at risk during the summer of 1981. Sixty three questionnaires were completed and returned (i.e. 20% response rate). Replies disclosed that more than 40% (41.3%) of respondents had never experienced a threatening natural hazard and none had suffered significant losses. Over half of those who had been affected by an evacuation advisory (29%) had ignored warnings to leave and had remained behind, usually because they evaluated personal risks as minimal. Thus, little more than one quarter of the sample (28.6%) had actual experience of an evacuation. Most respondents (54.2%) believed that emergency management was either not a problem for their community or that it was a low priority issue. Moreover, apart from Long Beach

Island, few respondents knew whether their community possessed an Emergency Management Plan or Hazard Zone land use controls. Despite this relatively low level of experience and knowledge, 88% of respondents expected that their communities would be evacuated at least once in the next 20 years and 60% felt that, two, three or more such evacuations would probably occur.

From the standpoint of emergency management, these are not encouraging findings. They suggest that many permanent coastal residents do not regard evacuation as a high priority problem, know little about it, and may well choose to ignore evacuation advisories when they are issued. While it can be argued that summer visitors may be more amenable to evacuation than permanent residents, it is also likely that permanent residents are more knowledgeable about local problems and have most to lose in a disaster. At the very least, evidence of lacklustre concern for emergency evacuation among permanent residents, should act as a caution to optimistic predictions that actual evacuations will proceed as smoothly as planned. These findings reinforce the need to build a "margin of safety" into evacuation time estimates to accomodate sub-optimal evacuation behavior on the part of residents and visitors in coastal New Jersey. They strengthen the case for interpreting Tables (4) and (5) as minimum, rather than maximum, evacuation time estimates.

ALTERNATIVE STRATEGIES

Clearly there is serious doubt that much of the New Jersey shore can be successfully evacuated in the face of an oncoming hurricane. The potential problems are most severe in Atlantic and Cape May counties but more northerly locations are also not immune from trouble. What might be done to increase the safety of populations at risk? Five alternatives will be briefly discussed:

(1) longer warning periods; (2) increased access to safe mainland areas; (3) hurricane resistant shelters in areas at risk; (4) improved emergency preparedness among populations at risk; and (5) reductions in the size of populations at risk. Each of these might be pursued alone or in combination with one or more of the others.

LONGER WARNING PERIODS

The National Weather Service has long recognized that many heavily populated areas cannot be evacuated within the lead times provided by Hurricane Warnings. (i.e. 24 hours) It is technically possible to provide earlier warnings but their reliability for specific sections of coastline is low.[29] Rather than designate large early warning areas and thereby encourage unnecessary concern among a majority of their inhabitants, a different approach has been adopted. On May 11, 1983 the Weather Service introduced a program for providing coastal communities with hurricane impact probabilities up to 72 hours before expected landfalls. Probability is defined as "... the chance in percent that the center of the storm will pass within approximately 65 miles of 44 selected locations from Brownsville, Texas to Eastport, Maine."[30] This is not a hurricane forecasting system; one based on feeding current data into forecast models. It instead assesses the performance of all past storms with the same track and forecast positions as the ongoing storm, and calculates the historical probability of impact for a range of onshore points; a hindcast rather than a forecast. Probabilities are issued four times a day as addenda to public advisories. They are intended to assist decision makers in local government and private industry who must begin protection measures more than 24 hours before forecasted storm landfall. Civil Defense officials who are responsible for evacuation are expected to be among the primary users of this service.

Since the program began, only one hurricane has struck the United States. Alicia passed over Galveston, Texas on August 19, 1983. It is instructive to review the Galveston experience.

The first probability statement was issued on August 15 when Alicia was still a tropical storm. (17% probability of striking Galveston) By 5 a.m. on August 16 its strongest winds had reached 50 m.p.h. and the probability of striking Galveston had risen to 19%. A Hurricane Watch was begun at 11 a.m. on the same day when wind speeds exceeded 65 m.p.h. (21%) This became a Hurricane Warning at 5 p.m. as winds attained 70+ m.p.h. (36%) Throughout the night, as wind speeds continued to increase, strike probabilities rose. By 5 a.m. on August 17 they reached 51%. This was the last time that the Weather Service issued a probability statement for Alicia. (As a storm approaches close to land and a strike becomes a virtual certainty, further probability messages are superfluous and possibly misleading.) Conditions worsened as the storm reached Category 3 on the Simpson/Saffir Hurricane Scale,(i.e. winds of 111-130 m.p.h.; storm surge 9-12 feet above normal) and the eye passed onshore over the western tip of Galveston Island at 1.30 a.m. on August 18.

Unfortunately, for the purposes of this study, the Mayor of Galveston declined to issue an evacuation order. (A previous study estimated that 26 hours are needed to complete evacuation of the city.) Hence, it is difficult to evaluate the usefulness of probability statements for accelerating the evacuation process. A sample survey of 200 people, carried out one month after Alicia, has disclosed that substantial numbers (44%) of Galveston residents left their homes during the 36-48 hours before the storm struck. Most of these (60%) sought shelter on the mainland.[31] However, the extent to which probability statements assisted this process is not yet known.

Given the fact that probabilities remain low (i.e. 10%-45%) during the period from 72-24 hours before landfall, it is possible that evacuation managers may not be sufficiently concerned about the likelihood of impact to begin sending people to safety. Twenty-four hours before a hurricane strikes New Jersey it could be as far away as South Carolina and 72 hours prior to landfall it might be in the Caribbean! Whether Civil Defense officials will be prepared to initiate evacuations in these circumstances is an unanswered question. It is too soon to evaluate the potential value of the new probability statements for coastal New Jersey, but they may provide an additional time cushion for hard pressed evacuation managers.

INCREASED ACCESS TO SAFE MAINLAND AREAS

The number of people who can be evacuated is partly a function of existing highway traffic capacities. In principle, it should be possible to reduce the time needed to empty areas at risk by adding more and larger highways or other transportation media. Unfortunately, this apparently simple solution is fraught with complications. For example, roads can generate traffic as well as accomodate it. Additional access points to barrier islands may make it easier for more visitors to enter these areas thus increasing, rather than decreasing, the size of populations at risk. New highways are expensive to construct and potentially controversial. Associated siting, environmental and other issues may generate considerable public opposition. It is also doubtful that additional highways are an answer for Cape May County's evacuation problem. There the entire county is at risk to hurricane driven floods and secure mainland highway routes could not readily be found. Moreover, elsewhere, the provision of increased access from barrier islands to the mainland may be insufficient because existing distributor roads such as the Garden State Parkway may not have adequate capacity to absorb larger traffic flows from barrier islands.

No attempt has been made here to explore the possibilities of building new railroad connections or resuscitate old railroad links. Nor have the possibilities of waterborne and airborne evacuation been explored. However, it is thought unlikely that these transportation media will be capable of making a significant quantitative contribution to improving the prospects for successful evacuation of vulnerable coastal areas.

HURRICANE RESISTANT SHELTERS IN AREAS AT RISK

One method of reducing the burden of hurricane evacuation is to create secure shelters in areas at risk. It is safe to assume that truly hurricane-proof buildings are rare, perhaps nonexistent. Winds in excess of 200 m.p.h. and storm surges of 18 feet will generally inflict severe damage on exposed coastal structures. However, most New Jersey hurricanes have been of a considerably lesser magnitude. For such storms, it is possible to construct hurricane-resistant buildings which offer considerable protection against high winds, floods and erosion. For economic reasons, this is generally only feasible in buildings that require large capital investments (e.g. high rise apartments, major public facilities). Moreover, such buildings require careful, siting, design, engineering and construction to stringent standards. It is not known how many, and to what degree, New Jersey coastal buildings are hurricane resistant. The largest single group of potentially storm resistant, high rise buildings (approximately 25), exists in Atlantic County. These include nine Atlantic City casinos, high rise apartment buildings and condominiums. A few others are scattered elsewhere along the coast (e.g. Monmouth Beach), but state law and regulations (i.e. Coastal Areas Facilities Review Act) precludes further high rise development for aesthetic, environmental and beach access reasons. Of the Atlantic County highrises, only the casinos possess formal evacuation plans. They typically expect that the threat of a hurricane will trigger efforts to keep buses from bringing incoming patrons to the casinos and will remove those who wish to leave. Existing customers who desire to keep playing will be permitted to do so and seaward casino exists will be locked. If conditions worsen, it is planned to move customers and staff to interior corridors on upper floors, where it is assumed they will be safe.

In principle, it may be possible to shelter large numbers of people in Absecon Island's high rise structures and perhaps elsewhere. However, for these to become realistic alternative public hurricane shelters, it will be necessary, at least, to conduct hurricane engineering certification studies keyed to storms of selected magnitude; to devise procedures for allocating populations at risk to appropriate buildings; and to persude building owners and operators to accept responsibility for sheltering the public. Given the few suitable buildings available, it is doubtful that barrier island hurricane shelters will play a significant role in reducing evacuation problems in Cape May County.

IMPROVED EMERGENCY PREPAREDNESS AMONG POPULATIONS AT RISK

This is not a separate alternative, but a necessary activity for ensuring the effectiveness of existing evacuation programs. For hurricane evacuation to work, it is imperative that the existing emergency management systems function quickly and smoothly.

All communities at risk possess local civil defense or emergency management coordinators who are responsible for developing emergency preparedness plans and overseeing evacuations and related activities. Their experience and expertise vary widely. Frequently, they are public officials, acting as emergency coordinators only in a part-time capacity. Local civil defense budgets are generally meager.

The four oceanfront counties possess emergency management coordinators and procedural plans for coping with a variety of hazards, including hurricanes. In some areas (e.g. Long Beach Island), county and local officials have devised special hurricane evacuation plans for entire barrier islands. During storm emergencies both county and local civil defense organizations cooperate closely with the state's official disaster management agency - the New Jersey State Police. They, in turn, join with the National Guard, Army Reserve, American Red Cross and other organizations. Over the last five years this emergency preparedness and management apparatus has performed relatively well during a series of winter coastal storms. However, it has not been seriously threatened by a hurricane since Belle (1976) - when several defects were uncovered - and it has not experienced even a peripheral hurricane strike for several decades.

The success of formal public preparations for coping with hurricanes is ultimately determined by the knowledge and participation of affected citizens. As has been shown, citizen awareness of hurricane risks is not high and familiarity with proper evacuation and safety procedures is relatively poor.

In order to maximize the effectiveness of existing evacuation programs, freater efforts need to be directed toward informing and educating the public about hurricanes and appropriate responses. Such efforts should not be confined to permanent populations in coastal communities. They should, at least, be statewide in scope and preferably include Pennsylvania communities that supply much of south Jersey's summer population.

REDUCTIONS IN THE SIZE OF POPULATIONS AT RISK

If fewer people required evacuation, the effectiveness of existing evacuation systems would be greatly enhanced, without resort to other measures.

Although it might be possible to discourage visits to the shore in the days preceding a possible hurricane, the practicalities of enforcing bans on travel to barrier islands or similar measures, are likely to be insuperable. It is more feasible to consider means for: (1) discouraging further, or more intense, development of exposed areas; (2) weakening existing incentives to remain in vulnerable localities; and (3) preventing redevelopment of damaged or destroyed property in the wake of a major storm.

Many parts of the Jersey shore are already heavily developed but intensification is possible in some places through the replacement of low density uses by high density uses. (e.g. single family houses replaced by apartment complexes) Such changes exacerbate evacuation problrms and should be avoided. It is possible to apply a wide range of planning and growth management techniques in pursuit of that goal (e.g. setback lines, zoning, infrastructure controls, public acquisition, public facility spending programs, tax and fiscal incentives etc.) To the extent that federally subsidized flood insurance provides incentives for investment in areas at risk, it may be worthwhile to raise premiums and restrict coverage on a specifically actuarial basis, thereby transferring the cost of post-disaster reimbursements away from the national Treasury to the risk-taking population. Similarly, public incentives for coastal investment in the form of bridge and highway subsidies, channel dredging projects, other "improvements" and cost-sharing programs could be amended to minimize the attractions of developing or redeveloping high risk locations. Finally, post-disaster redevelopment plans with special hurricane mitigation features and strict enforcement of prohibitions on the reconstruction of damaged facilities, might be prepared in anticipation of future losses. This could ensure that post-disaster redevelopment pressures do not recreate or add to existing evacuation problems. At least one New Jersey community is known to possess such a plan. (i.e. Avalon)

SUMMARY

This study has developed a number of hurricane vulnerability scenarios for the coast of New Jersey. These suggest that the existing potential for disaster is substantial and growing. They demonstrate that evacuation programs offer insufficient protection to populations at risk in Cape May County, Atlantic County and parts of Ocean County.

The southern half of New Jersey's oceanfront is most exposed to storms that may compel evacuation. It contains the largest summer populations at risk to hurricanes and it is the area with greatest potential for future coastal population growth. During peak summer vacation periods perhaps 0.75 to 1.75 million people are at risk along the state's shorefront. Approximately 90% (89%-91%) of these are located in the area between Long Beach Island and Cape May.

Under the assumptions used in this study, Cape May County poses the most serious evacuation difficulties and may require up to 23 hours for total evacuation during peak summer periods. (Table (5)) Absecon Island (7.1-16.4 hours) and Long Beach Island (3.5-9.3 hours) also face serious evacuation problems. Given the likelihood that exit highways may be closed by adverse weather conditions up to 5 hours before the arrival of a hurricane; bearing in mind the generally low level of preparedness among local residents; and in view of the fact that only 6-12 hours warning may be possible, it is unlikely that these locations can be successfully evacuated in advance of a fast moving hurricane. Even a slow moving hurricane has the potential to cause disaster in some communities.

It is possible that no major hurricane will threaten the New Jersey coast for many years. If so, it is likely that the present highly vulnerable state will grow even more precarious. Given a repeat of the Cape May hurricane of September 1821, for example, losses are likely to be heavy.

Serious thought must be given to reinforcing traditional evacuation systems with a mix of alternative protection strategies. Evacuation managers may increasingly have to adjust the timing of evacuations to schedules based on hurricane probability data rather than the more conventional Hurricane Watch and Warning system. A determined effort to improve public understanding of hurricane risks and evacuation procedures is warranted. It may be necessary to increase road access from barrier islands, and other locations at risk, to safe mainland areas. It may also be necessary to develop a safety certification program for high rise structures and to formulate associated contingency plans for vertical evacuation in some locations. Taken together all of these measures will undoubtedly improve the safety of coastal populations. Whether they will be sufficient to forestall disaster is questionable. Perhaps the safety of New Jersey's coastal population can only be assured by permanently reducing the size of numbers at risk through growth management, development controls and risk sensitive post-disaster redevelopment policies.

APPENDIX I

CALCULATION OF PEAK SEASONAL POPULATIONS: EXAMPLES

I. Dames and Moore data ("high peak population estimate")

Community: Harvey Cedars
Seasonal Population Ratio: 14
Permanent Population: 363
Peak Seasonal Population: (363) X (14) = 5,082

II. Rogers, Golden and Halpern data ("low peak population estimate")

Community: Harvey Cedars

(a) Annual Total of Visitor Days (by category)

Seasonal home	399,420
Hotel/Motel	6,311
Campground	0
Friend/Relative	2,716
Day Party	28,946

(b) Convert to number of visitors by dividing each figure by the appropriate average length of stay (i.e. Seasonal home: 14.2 days; Hotel/Motel: 4.3 days; Friend/Relative: 8.3 days; Day Party: 0.33 days)

Number of Visitors

Seasonal home	28,128
Hotel/Motel	1,468
Friend/Relative	327
Day Party	86,838
TOTAL:	116,761

(c) It is known that July is the peak vacation month and that 36% of all visitors are at the shore during this month. Therefore, the average July daily number of visitors is:

$$\frac{116{,}761 \text{ X } 36}{31 \text{ X } 10} = 1{,}356$$

(d) Sample traffic surveys indicate that peak visitor days (Saturdays and Sundays) attract approximately 20% more people than the monthly average. Therefore, a peak July day will attract:

$$\frac{1356 \text{ X } 120}{100} = 1{,}627 \text{ visitors to Harvey Cedars}$$

(e) Total peak summer population = Permanent population + peak July day population.

(363) + (1,627) = 1,990

Harvey Cedars peak summer population: 1,990

APPENDIX II

EVACUATION ROUTE TRAFFIC VOLUMES*

A.

BARRIER ISLAND ROUTES TO MAINLAND	30th PEAK HOUR	CAPACITY
1. Cold Spring-Wildwood Crest	890	1,600
2. Garden State Parkway-Wildwood (Rt.47)	1,485	2,325
3. Garden State Parkway-North Wildwood (Rt.147)	1,258	1,540
4. Garden State Parkway-Stone Harbor (Rt.29)	779	1,620
5. Garden State Parkway-Avalon (Rt.1)	415	1,200
6. Garden State Parkway-Sea Isle City (Rt.25)	562	1,500
7. Garden State Parkway-Ocean City (Rt.23)	1,328	1,634
8. Somers Point-Ocean City (Rt.52)	632**	1,547**
9. Atlantic Cty. Rt.157-Longport (Rt.152)	540	1,780
10. Northfield-Margate City (Rt.563)	898	1,880
11. Pleasantville-Atlantic City (US 40/322)	2,503	4,807
12. Pleasantville-Atlantic City (At.City Ex-way)	4,012	5,880
13. Absecon-Atlantic City (US 30)	3,312	5,460
14. Manahawkin-Ship Bottom (Rt.72)	4,171	5,100
15. Bay Shore-Seaside Heights (Rt.37)	6,757	8,550
16. Adamston-Mantoloking (Rt.528)	1,080	1,595
17. Sea Bright-Rumson (Rt.520)	634	1,656
18. Atlantic Highlands-Highlands Beach (Rt.36)	2,298	4,860

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*Volumes in numbers of vehicles per hour. Figures adjusted to reflect use of both lanes on two lane highways and 3 of 4 lanes on four lane highways. Source: George E. Thomas, N.J. Department of Transportation.

**Estimated data, based on assumed constriction of Rt.52 traffic by concurrent use of Rt.585 and Rt.9 in Atlantic County.

APPENDIX II (cont.)

B.

INTER-ISLAND BRIDGES*	30th PEAK HOUR	CAPACITY
1. Rt.47- Stone Harbor (Rt.30)	750	2,250
2. Avalon-Sea Isle City (Townsends Inlet Bridge)	377	1,500
3. Strathmere-Ocean City (Corson Inlet Bridge)	278	1,500
4. Ocean City-Longport (Great Egg Harbor Inlet)	936	1,600
5. Atlantic City-Brigantine (Rt.87)	1,136	1,780

[*] Data for information only. Not used to calculate evacuation rates because of assumption that these bridges would be closed to traffic in advance of hurricane.

C.

MAINLAND EXIT ROUTES	30th PEAK HOUR	CAPACITY
1. Dennisville-Eldora (Rt.47)	990	1,377
2. Woodbine-Belleplain (Rt.550)	224	1,565
3. Petersburg-Tuckahoe (Rt.50)	1,296	1,411
4. Marmora-Somers Point (US 9)	632	1,547
5. Garden State Parkway (Exits 25-29S)	5,647	10,920
6. Bay Head-Point Pleasant (Rt.13)	822	4,080
7. Bay Head-Garden State Parkway (Rt.34)	3,727	4,280

APPENDIX III

SAMPLE DERIVATION OF EVACUATION TIMES

(1) Identify communities at risk on each barrier island or segment of barrier beach. (e.g. The Wildwoods include Wildwood Crest, Wildwood and North Wildwood. They occupy the barrier island between Cold Spring Inlet and Hereford Inlet).

(2) Calculate total high peak population at risk in The Wildwoods.

North Wildwood	70,710
Wildwood	98,260
Wildwood Crest	47,299
Total:	216,269

(3) Specify the hourly rate of vehicular evacuation, via all routes to mainland, for two levels of flow: (a) 30th peak hour flow; (b) route capacity flow; both in numbers of vehicles per hour.

	30th peak hour	capacity Flow
(a) Cape May county road, Cold Spring to Wildwood Crest	890	1,600
(b) State Highway 47, Garden State Parkway to Wildwood	1,485	2,325
(c) Cape May county road 147, Garden State Parkway to North Wildwood	1,258	1,540
TOTALS:	3,633	5,465

(4) Calculate hourly rates of Population evacuation assuming an average of 4 persons per vehicle.

(a) 30th peak hour: 3,633 X 4 = 14,532 people

(b) Capacity flow: 5,465 X 4 = 21,860 people

(5) Calculate time required for all evacuation vehicles to leave barrier island by dividing peak population at risk by hourly rates of population evacuation.

(a) 30th peak hour: $\frac{216,269}{14,532}$ = 14.9 hours

(b) Capacity flow: $\frac{216,269}{21,860}$ = 9.9 hours

(6) Calculate total evacuation time by adding 1.0 reaction time required to initiate evacuation after receipt of evacuation message, and 1.0 hours

for travel time between Wildwood and adjacent mainland location.

(a) 30th peak hour: 14.9 + 2.0 = 16.9 hours

(b) Capacity flow: 9.9 + 2.0 = 11.9 hours

NOTES

1. Robert H. Simpson and Herbert Riehle, The Hurricane and Its Impact (Baton Rouge: Louisiana State University Press, 1981), 366-368.
2. U.S. Department of the Interior, Undeveloped Coastal Barriers: Report to Congress (Washington, D.C.: U.S. Government Printing Office, 1981), p.1.
3. U.S. Congress, Omnibus Budget Reconciliation Act of 1981 (P.L.97-35), Section 341 (D).
4. U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Flood Hazard Mitigation Through Safe Land Use and Construction Practices: New Jersey Coastal Area Field Test Report, (Chicago: Sheaffer and Roland, Inc., 1976).
5. New Jersey, Department of Environmental Protection, Division of Coastal Resources, Shore Protection Master Plan (Cranford: Dames and Moore, 1980), Pp. D 41-42.
6. In some parts of the Middle Atlantic states the difference between wave crest elevations and stillwater elevations is 4-5 feet.
7. National Research Council, Committee on Coastal Flooding from Hurricanes, Evaluation of the FEMA Model for Estimating Potential Coastal Flooding from Hurricanes and Its Application to Lee County, Florida (Washington, D.C.: National Academy Press, 1983).
8. Paul Gares, Karl F. Nordstrom and Norbert P. Psuty, Coastal Dunes: Their Function, Delineation, and Management (New Brunswick: Rutgers University, Center for Coastal and Environmental Studies, 1979).
9. New Jersey, Shore Protection Master Plan, pp.II4-II31 and A-1 to A-8.
10. N. Arthur Pore and Celso S. Barrientos, Storm Surge, MESA New York Bight Atlas Monograph 6 (Albany: New York Sea Grant Institute, 1976).

11. New Jersey, Shore Protection Master Plan, p. II-13.

12. New Jersey, Shore Protection Master Plan, p. II-20.

13. Pore and Barrientos, Storm Surge, p.34.

14. Strong winter storms in October 1980 ~~and March~~ 1984 precipitated limited evacuations along much of the Atlantic shorefront of New Jersey.

15. Robert H. Sinpson and M.B.Lawrence, Atlantic Hurricane Frequencies Along the U.S.Coastline, NOAA Technical Memorandum #NWS SR-58 (Washington, D.C.: Department of Commerce, 1971)

16. Highrise buildings have been identified as potential hurricane shelters in Miami Beach, New Orleans and elsewhere. Limited recent experience with direct hurricane strikes on major U.S. urban centers (e.g. "Alicia" on Houston, Texas, 1983) suggests that failure of cladding and debris damage to windows on highrise towers, can be significant problems when winds exceed 75 m.p.h.

17. County Planning Board projections reveal similar increases. For example, in Cape May it is estimated that there will be 147,130 permanent residents in 2000 A.D. (80% increase over 1980) with 720,500 present on"an average Saturday" in July or August.See: Cape May County Planning Board, Population Projections for Cape May County 1970-2010, November, 1973.

18. Quoted on WCBS radio, December 6, 1983.

19. New Jersey, Shore Protection Master Plan, pp. A-35 to A-36.

20. New Jersey, Department of Environmental Protection, Division of Coastal Resources, Impacts of Coastal Energy Development on New Jersey's Shorefront Recreational Resources· Summary Report, prepared by Rogers, Golden and Halpern; Philadelphia (Trenton, 1984), p. 6. (3 volumes plus Summary)

21. "Analysis of the Evacuation of Long Beach Island: Phase II," Dames and Moore, Cranford, New Jersey, July 1977.

22. Earl J. Baker, ed., Hurricanes and Coastal Storms: Awareness, Evacuation and Mitigation, Florida Sea Grant College Report #33, Tallahassee, 1980, pp.13-58.

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24. "Analysis of the Evacuation of Long Beach Island: Phase II," Dames and Moore, Cranford, New Jersey, July 1977.

25. Some local communities possess limited capabilities to predict storm tracks based on locally available information. Cape May County employed a meterologist in its Civil Defense organization who monitored storm tracks and programed evacuation scenarios on a personal computer.

26. Neil Frank, "Overview of the Hurricane Problem," paper presented at the Hurricane Awareness Workshop: Probabilities, Atlantic City, May 30, 1984.

27. Simpson and Riehl, The Hurricane and Its Impact, p. 368.

28. Six hours is a conservative estimate. For example, a recent study of hurricane evacuation problems in South Florida indicates that gale force winds can occur 6-14 hours before hurricane landfall. Lower Southeast Florida Hurricane Evacuation Study: Technical Data Report, (Jacksonville: U.S. Army Corps of Engineers, 1983), p.44.

29. T. Michael Carter, Probability of Hurricane/Tropical Storm Conditions: A User's Guide for Local Decision Makers, U.S. Department of Commerce, NOAA, June, 1983, pp.2-6.

30. U.S. National Weather Service, "Fact Sheet for Hurricane/Tropical Storm Probabilities," August, 1983.

31. Survey by Earl J. Baker, reported at the National Hurricane Conference, Tampa, Florida, may, 1984.

Dr. **Mitchell**. I will try to be as brief as possible. The southern half of New Jersey's oceanfront from just north of Atlantic City to Cape May County is the most exposed part of the State of New Jersey to hurricanes. It's about 53 miles long, and it includes all of Cape May County and the inhabited islands of Atlantic County—that's Brigantine Island and Absecon Island. The problem here is that you have a combination of very low elevations; much of the area is below 15 feet above mean sea level, as well as a very impoverished state of sand dune protection, natural protection. In many cases there are no sand dunes on the shore, and where they do exist, they are usually very low and very narrow. That's combined, in addition, with serious beach erosion.

So when you put all of these three things together, you'll find that most of this two-county shorefront is likely to be inundated by the 9- to 12-foot storm surge that typically accompanies a major hurricane. This is a class 3 hurricane on the Simpson-Saffir scale.

If a hurricane threatens New Jersey during the summer vacation season, the communities at risk will be crowded with visitors. The best available estimates suggest that up to 1.75 million people may be present in vulnerable areas at peak periods, about 80 percent of that number in Atlantic and Cape May Counties.

Most of these potential victims, the temporary residents and the permanent residents, depend for their safety on road evacuation. This can require journeys of between 20 and 35 miles across several bridge and causeway crossings. Unfortunately, it's unlikely that total evacuations can be successfully completed in all vulnerable communities before the arrival of an oncoming hurricane.

In my written testimony I have prepared a table which sets out various time estimates of the number of hours before hurricane landfall that evacuation needs to be begun in order to be successfully completed before the arrival of an oncoming hurricane. The range of evacuation times is from 6.6 hours to 29.7 hours, with the longest evacuation times being recorded in the two most vulnerable counties, Cape May County and Atlantic County.

So you have the area of New Jersey that's most exposed to hurricanes and has the largest population at risk, also having the longest evacuation time.

With 24 hours warning, most vulnerable New Jersey communities can be evacuated; but parts of Cape May County may experience some serious problems during peak summer population periods.

Now, we've been told that we don't get 24 hours warning. With 12 hours warning, Atlantic City and adjacent communities cannot be successfully evacuated—that's if you are thinking of removing all of the population at risk right off the vulnerable barrier islands and low-lying, mainland shores.

Mr. **Scheuer**. In Atlantic City—excuse the interruption—do you have enough highrise structures to deal with an emergency?

Dr. **Mitchell**. Probably not, but I haven't conducted the kind of investigation that's able to give you a precise answer on that. There are about 25 highrise structures, including 9 casinos, most of which are on the oceanfront. The casinos do have evacuation plans, but they are for their own patrons and they generally involve encouraging the patrons onsite to stay there rather than to leave, but turning away the incoming patrons in buses and providing buses for those of the current patrons to leave, locking the seaward doors, and—as a last resort—moving the patrons to the upper interior floors, where it is presumed that they will be safe. But you don't have a hurricane safety certification program; there's no system for identifying which people should go to which highrises, if indeed they are safe; and basically, there's no agreement between the owners and the operators of the highrises to accommodate the general public.

So there are a wide range of issues that would have to be looked at long before you could consider those as feasible. In Cape May County, there are very few highrise buildings, so it's really not feasible at the moment.

To come back to the testimony, with 12 hours you basically can't evacuate much of this area within Atlantic County, including Atlantic City. The same is true for most of Cape May County except at low population periods, with substantially less than 12 hours; and that time's quite feasible, given the fact that hurricanes accelerate as they move up the east coast. With less than 12 hours, evacuation problems arise virtually everywhere along the New Jersey shore.

So from these data, it appears that evacuation cannot be relied upon to ensure the safety of the New Jersey coastal populations at risk to hurricanes.

Now, those figures really understate the seriousness of the evacuation problem because they assume that the affected populations will respond smoothly and efficiently to evacuation orders, and that the entire formal warning and evacuation process will operate as planned.

A survey of permanent residents in vulnerable communities indicates that a large number—54 percent, in fact, of the survey—do not regard evacuation as a high priority issue. Many have not experienced damaging coastal storms, 41 percent, or they have ignored previous evacuation orders, 29 percent. In other words, among the permanent residents at risk, levels of knowledge, experience and concern about hurricane evacuation are relatively low. The summer visitors—that was just the permanent population—the summer visitors are no better acquainted with evacuation procedures and no better prepared to confront hurricanes. These are not favorable portents for future large-scale evacuation.

The conclusions reported here cast serious doubt on the wisdom of relying heavily on evacuation as a principal hurricane safety measure. They are based on a statewide survey of vulnerability undertaken before NOAA's SLOSH model became operational for New Jersey coastal areas, or at least for parts of the coast.

The SLOSH model is a useful tool for identifying areas that are likely to be flooded by hurricane surges. This makes it relatively easy to determine potential property losses for buildings and to work out property damage mitigation programs. If we know how many people are likely to be occupying those buildings, it's also easy to assess the evacuation needs and begin devising evacuation strategies. But when we don't know how many people are at risk or what types of people are at risk in the areas that the SLOSH data indicates are hazardous, then the evacuation planning is much more difficult; and, unfortunately, that's what occurs throughout most of the Northeastern United States.

We believe the number of transient summer residents may be 9 or 10 times the permanent winter population, but the lack of systematic seasonal population data for New Jersey and other Northeastern States seriously hampers any analysis of coastal storm evacuation.

So I think high priority should be accorded to conducting a summer population census or comparable study of seasonal population in the Northeastern States.

What might be done to increase the safety of populations at risk? I think serious thought must be given to reinforcing traditional evacuation systems with a mix of alternative protection strategies. Some of these we've already heard about, but I'll summarize them very briefly.

Evacuation managers may increasingly have to adjust the timing of evacuations to schedules based on hurricane probability data rather than more conventional hurricane watch and warning procedures.

A determined effort to improve public understanding of hurricane risks and evacuation actions is warranted.

It may be necessary to improve road access from barrier islands to safe mainland areas.

It may also be necessary to develop a safety certification program for high-rise structures, and to formulate contingency plans for vertical evacuation and sheltering of the general public in some locations.

Taken together, all of those measures will undoubtedly improve the safety of coastal populations. Whether they will be sufficient to forestall disaster is considerably much more difficult to answer.

In the long run, the safety of New Jersey's coastal populations and probably those of the other Northeastern States can probably only be assured by a continuing storm hazard mitigation program that combines a number of things: public measures to acquire and vacate particularly high-risk areas—we're not talking about large areas of shoreline, just high red-flag spots; measures to discourage further development of exposed sites; measures to weaken public incentives to remain in vulnerable locations, like those offered through the Flood Insurance Program; and measures to prevent unwise redevelopment of damaged or destroyed property in the wake of a major storm.

Thank you.

[The prepared statement of Dr. Mitchell follows:]

STATEMENT BY JAMES K. MITCHELL, RUTGERS UNIVERSITY

My name is James K. Mitchell. I am a Professor of Geography and Director of the Graduate Program in Geography at Rutgers University, New Brunswick, New Jersey. For the past 15 years I have been studying natural hazards in coastal areas. Since 1980 this has included research on the evacuation of New Jersey communities that are at risk to hurricanes.

Together with other Northeastern states (i.e. Maryland-Maine), New Jersey faces hurricane hazards that are somewhat different from the more widely known problems of the Gulf of Mexico and the south Atlantic coast states. In the northeast the chief differences include: (1) a greater likelihood of being affected by fast moving hurricanes, leading to foreshortened warning periods; (2) a more or less continuously and heavily developed coastline, still undergoing significant population growth; (3) disproportionately large numbers of temporary residents and day visitors during the summer hurricane season; and (4) relatively little recent experience with major hurricanes. Taken together, these differences mean that the Northeast is considerably more vulnerable to hurricanes than are most other parts of the United States coast.

Fully fledged hurricanes have struck Northeastern states nine times since 1900. Four of these have been major, fast moving storms (1938, 1944, 1954, 1960) with peak winds in excess of 110 m.p.h. and forward speeds of more than 30 m.p.h. Between them these four hurricanes killed more than 750 people and each inflicted damages varying between $50 million and $500 million (unadjusted).

Each Northeastern state faces a different mix of hurricane problems, but New Jersey's situation is fairly representative. Compared to Long Island or Cape Cod, for example, the New Jersey coast has a significantly lower risk of being struck by a hurricane, but a combination of dense oceanfront development, large summer populations and limited evacuation opportunities, makes New Jersey more vulnerable to hurricane losses. In the twentieth century, New Jersey has experienced only limited and infrequent hurricane damage. Apart from a direct strike by a minor hurricane in 1903, the Jersey shore has felt only the edge effects of two major and two minor hurricanes (1924,1944,1960,1976). The most recent (Belle, 1976) caused no deaths or injuries but inflicted approximately $17 million in economic losses. This is only a small fraction of potential losses. The value of property and structures on New Jersey's barrier islands alone is approximately $5.5 billion (1980).

The fact that New Jersey has not experienced a major hurricane in this century does not mean that it is immune to future hurricane damage. Minor conceivable changes in the alignment of past hurricane tracks would have placed the state's coastal population at great risk. There is also evidence of major hurricane strikes on the New Jersey coast in the early nineteenth century (1815, 1821) and perhaps at other times when few people lived near the shore and detailed records were not kept. If such storms were to reoccur today, heavy losses would likely result. In short, thus far New Jersey has been lucky to escape major hurricanes.

The southern half of New Jersey's oceanfront, from just north of Atlantic City to Cape May, is most exposed to hurricane hazards. This 53 mile frontage includes all of Cape May County and the inhabited islands of

Atlantic County (i.e. Brigantine Island, Absecon Island). It is an area of lowlying,narrow, sandy barrier islands and wetlands. Few places are more than fifteen feet above sea level. There is little natural protection against storm surges because the dunes are low and narrow or nonexistent, and many of the beaches suffer critical erosion problems. The minimum 9 to 12 foot surge that typically accompanies a major hurricane is likely to inundate most of this area.

If a hurricane threatens New Jersey during the summer vacation season (i.e. July, August), communities at risk will be crowded with visitors. It is impossible to be certain of the exact numbers involved, but the best available estimates suggest that up to one and three quarter million (1.75 million) people may be present, in vulnerable areas, at peak periods. This is nine times the permanent (winter) population. Approximately 80% of these people will be located in Cape May County and Atlantic County.

Most potential victims depend for their safety on evacuation by road. This can require journeys of 20 to 35 miles over several bridge and causeway crossings. Unfortunately, it is unlikely that total evacuations can be successfully completed in all vulnerable communities before the arrival of an oncoming hurricane. Table (1) shows the estimated number of hours before hurricane landfall that evacuation must begin to ensure the complete removal of populations at risk. Evacuation times are calculated for two levels of summer population (high, low) and two volumes of road traffic (typical rush hour, highway design capacity). They range from a minimum of 6.6 hours to a maximum of 29.7 hours, with the longest evacuation times being recorded in Cape May County and Atlantic County. Thus the area of New Jersey which is most exposed to hurricanes also has the largest population at risk and the longest evacuation times.

The National Hurricane Center plans to issue Hurricane Warnings 24 hours before expected landfall but it is widely believed that Northeastern states cannot be guaranteed more than 6 to 12 hours warning because East Coast hurricanes generally pick up speed as they move north. With 24 hours warning most vulnerable New Jersey communities can be evacuated, but parts of Cape May County may experience serious problems at peak summer population periods. With 12 hours warning Atlantic City and adjacent communities cannot be successfully evacuated. The same is true for most of Cape May County except at low summer population periods and under very favorable road traffic conditions. With substantially less than 12 hours warning, evacuation problems arise virtually everywhere along the New Jersey shore. From these data, it appears that evacuation cannot be relied on to ensure the safety of New Jersey coastal populations at risk to hurricanes.

Table (1) understates the seriousness of the evacuation problem because it assumes that affected populations will respond smoothly and efficiently to evacuation orders and that the entire formal warning and evacuation process will operate as planned. A survey of permanent residents in vulnerable communities indicates that a large number do not regard evacuation as a high priority issue (54%); many have not experienced damaging coastal storms (41%), or have ignored previous evacuation orders (29%). In other words, among permanent residents at risk, levels of knowledge, experience and concern about hurricane evacuation are relatively low. Summer visitors

TABLE (1)

ESTIMATED GENERAL EVACUATION TIMES[1]

Communities At Risk	High Peak Population[2]		Low Peak Population[3]	
	Typical Rush Hour Traffic	Highway Capacity	Typical Rush Hour Traffic	Highway Capacity
Monmouth County				
Sea Bright	8.6	8.0	7.4	7.1
Monmouth Beach	6.8	6.6	6.7	6.6
Ocean County				
Northern[4]	10.9	?	10.3	?
Mid-County[5]	14.0	11.7	10.3	9.2
Long Beach Island	14.3	12.9	8.8	8.5
Atlantic County				
Absecon Island[6]	21.4	17.4	14.0	12.1
Cape May County				
Peck Beach[7]	27.0	19.2	12.4	10.9
Ludlam Island[8]	19.4	12.2	13.8	10.2
Seven Mile Beach[9]	14.7	10.8	11.2	9.2
Five Mile Island[10]	22.9	17.9	11.6	10.4
Mainland Cape May County	29.7	18.6	14.0	11.4

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[1] Time reported in hours

[2] Total: 1,755,927

[3] Total: 747,303

[4] Point Pleasant Beach to Chadwick Beach

[5] Lavallette to Island Beach State Park

[6] Brigantine, Atlantic City, Ventnor, Margate, Longport

[7] Ocean City

[8] Strathmere, Sea Isle City

[9] Stone Harbor, Avalon

[10] North Wildwood, Wildwood, Wildwood Crest, West Wildwood

are no better acquainted with evacuation procedures and no better prepared to confront hurricanes. These are not favorable portents for future large scale evacuations.

The conclusions reported here cast serious doubt on the wisdom of relying heavily on evacuation as a principal hurricane safety measure. They are based on a statewide study of hurricane vulnerability undertaken before NOAA's SLOSH model became operational for New Jersey coastal areas. In the future, SLOSH data will assist the completion of detailed site specific, hurricane vulnerability studies by clarifying places at risk to hurricane surges, but that information will lose much of its value unless it also becomes possible to, more accurately, determine the numbers of people at risk. At present, the lack of systematic, seasonal population data for New Jersey and other Northeastern states seriously hampers any analysis of coastal storm evacuation. High priority should be accorded to conducting a summer population census or a comparable study of seasonal population in Northeastern coastal states.

What might be done to increase the safety of populations at risk? Several alternatives are possible. Each of these might be pursued alone or in combination with one or more of the others.

First, it may be possible to increase the effective hurricane warning time. The National Weather Service has begun a new program for providing coastal communities with hurricane impact probabilities up to 72 hours before expected landfalls. These are not forecasts in the conventional sense, but are based on the performance of all past storms with the same track and forecast positions as an ongoing storm. If this information proves to be reliable, and if New Jersey evacuation managers are prepared to order early evacuations based on it, then the system may provide additional time for vulnerable communities.

Second, it is possible to improve road access between vulnerable coastal areas and safe mainland sites. However, this is a double-edged sword because roads can generate traffic and attract more shore users as well as accomodate evacuation vehicles. It is doubtful that additional highways are an answer for Cape May County, because the entire county is at risk to hurricane driven floods and safe new mainland highway routes cannot easily be found.

Third, the burden of hurricane evacuation might be reduced by sheltering people inside secure highrise buildings in vulnerable areas. For example, there are approximately 25 such buildings on Absecon Island, including 9 Atlantic City casinos. The casinos possess formal evacuation plans. These typically include preparations to turn away incoming patrons and use the available empty buses to remove those who wish to leave. Existing customers who want to continue gambling will be permitted to do so and seaward casino exits will be locked. If conditions worsen, it is usually planned to move customers and staff to interior corridors on upper floors, where it is assumed they will be safe. For Atlantic County's highrises to become realistic alternative public hurricane shelters, it will be necessary to; conduct hurricane engineering certification studies, to devise procedures for allocating populations at risk to appropriate buildings; and to persuade building owners and operators to accept responsibility for sheltering the public. So-called "vertical evacuation" may never be feasible in Cape May County, because there are few potentially suitable buildings and coastal zone management regulations discourage their construction.

Improved emergency preparedness will help to maximize the effectiveness of existing evacuation programs. The success of such programs is ultimately determined by the knowledge and participation of affected citizens. In view of the relatively low levels of citizen awareness of hurricane risks and evacuation procedures, greater efforts need to be directed toward informing and educating the public about hurricanes and appropriate responses.

Taken together, the preceding measures will undoubtedly improve the hurricane safety of coastal populations. Whether they will be sufficient to forestall disaster is questionable. In the long run, the safety of coastal populations in the Northeast may best be assured by permanently reducing the numbers of people who require evacuation. This can probably only be done by determined implementation of a continuing storm hazard mitigation program that combines: (1) public measures to acquire and vacate particularly high risk areas; with (2) measures to discourage further development of exposed sites; (3) measures to weaken public incentives to remain in vulnerable localities; and (4) measures to prevent unwise redevelopment of damaged or destroyed property in the wake of major storms.

Mr. **Scheuer**. Thank you very much.
Ms. Ehinger.

STATEMENT OF RUTH EHINGER, DIVISION OF COASTAL RESOURCES, DEPARTMENT OF ENVIRONMENTAL PROTECTION, STATE OF NEW JERSEY

Ms. **Ehinger**. I appreciate the opportunity to discuss storm evacuation planning in New Jersey, which is the responsibility of the division of coastal resources in the department of environmental protection, and also the State police.

I am Ruth Ehinger, and I am a principal environmental specialist in the division of coastal resources and I'm testifying on behalf of myself and John Weingart, who is the director of the division and responsible for the Coastal Management Program.

I want to emphasize today that New Jersey must have the ability to predict flood elevations in order to prepare evacuation plans for the State. The shore communities of New Jersey, many of which are barrier islands connected to the mainland by only one or two causeways, will have hundreds of thousands of people on them on a regular basis, and especially high populations in the summer months, which is the hurricane season.

The barrier island and oceanfront communities of New Jersey are all densely developed at the present time, and are becoming increasingly developed as single family residences convert to condominium developments.

The susceptibility of the New Jersey coast was demonstrated this March, when a northeast storm of only a 10-year frequency resulted in a Presidential disaster declaration, and cut off the islands of Brigantine and Absecon, which do contain the city of Atlantic City, from the mainland for several hours, isolating the winter population of 70,000 people. In the summer we would expect that to be upwards of 275,000 people.

The public is basically unaware of the magnitude of storm hazard that they face, and, indeed, many of them justify this feeling of theirs that they have survived storms like this one we just had, that their homes were not damaged and therefore they will withstand any storm that faces New Jersey.

We need the technical expertise of the National Weather Service to predict storm effects and to enable us to evaluate the vulnerability of the shore and conduct evacuation planning. Our present predictions are poor due to lack of modeling capability, lack of data—both historical storm data and topographic and bathymetric data, which is needed to judge what surge effects will be, and in particular in the back bay portions of New Jersey.

SLOSH would allow us to make such predictions for various hurricane tracks and intensities. We are interested in calibration of the existing Delaware Bay model to enable us to make reliable predictions. At the present time, this model can only be used in the Atlantic City area; and in particular, in south Jersey from Manasquan Inlet down to Cape May, we do feel that this is a critical point.

We're also interested in development of this model to finer resolution so that the surge predictions can be made on the order of half-mile error rather than 2- to 3-mile, and we also feel that a model is needed for north Jersey and the Raritan Bay area.

These models would be used by the State in evacuation planning, vulnerability analyses, and land use planning. In particular, we would also like to use this for public education. When the State, with the knowledge that we have, tries to indicate to the public that there is a problem, they really do not believe us; and we feel that this type of information would be very helpful in that regard.

New Jersey is considered to have one of the best coastal management programs in the country; yet, our knowledge is obviously not complete. We know that other coastal States face these situations that are at least as serious. If the storm comes in the summer when our beachfront communities are packed with people, everyone will realize that we should have used every available workable tool to predict and plan for this event. If we are able to continue to develop SLOSH models for New Jersey, we believe we will be able to substantially reduce the loss of life and, perhaps, of property, as well.

[The prepared statement of Ms. Ehinger follows:]

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
TRENTON

PLEASE ADDRESS REPLY TO:
CN 401
TRENTON, N. J. 08625

DIVISION OF COASTAL RESOURCES

TESTIMONY BEFORE THE HOUSE SUBCOMMITTEE ON NATURAL RESOURCES

JOHN R. WEINGART, ACTING DIRECTOR
and RUTH EHINGER of the
DIVISION OF COASTAL RESOURCES
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
CN 401
TRENTON, N.J. 08625
August 9, 1984

Thank you for the opportunity to discuss storm evacuation planning in New Jersey. This planning is the joint responsibility of the Divisions of Coastal Resources and Water Resources in our Department of Environmental Protection and of the State Police. During a storm emergency, the State Police is the State's lead agency.

My name is Ruth Ehinger and I am a Principal Environmental Specialist in New Jersey's Division of Coastal Resources. I am speaking today on behalf of myself and of John R. Weingart, who is the manager of New Jersey's federally approved Coastal Management Program.

I want to stress to you today the need for accurately predicting hurricane flood elevations on the New Jersey coast to enable the State to prepare plans to protect the hundreds of thousands of people on barrier islands and other coastal communities during hurricane season. The SLOSH model would predict and map areas of storm surge inundation, a capability which is presently lacking in New Jersey. This information would be used in evacuation and land use planning, and to educate the public on storm awareness, hazards and response.

The area of New Jersey where citizens are in the greatest danger from the effects of coastal storms, particularly hurricanes, is located between Manasquan Inlet and Cape May Point. This area includes the densely populated barrier islands of Ocean, Atlantic and Cape May Counties. The vulnerability of this area is demonstrated by the fact that a relatively minor storm on March 29, 1984 resulted in a Presidential disaster declaration. For several hours, the storm cut off all evacuation routes from Absecon and Brigantine Islands, which have a year round population over 70,000 and an average daily seasonal population estimated at upwards of 275,000.

In order to plan for protection of life and property from coastal storms, coastal states must know the expected level and likely location of inundation from coastal flooding. The Sea, Lake, Overland Surge from Hurricane (SLOSH) model is a computer model developed by the National Weather Service which will predict surge levels for storms of certain magnitudes at upland locations both on the oceanfront and on other tidal waterways. Predicted surge levels and areas of inundation would be shown on contour maps for the entire model area. Presently, we are able to estimate surge levels for specific sites, but cannot make predictions for large areas such as an entire municipality or island. The model also predicts tidal flooding, high water lines, hurricane landfall or along shore movement, and maximum wind velocities associated with various intensity storms for specific areas.

New Jersey currently has insufficient data to make useful predictions concerning storm impacts. The flooding patterns of the March 1984 storm demonstrated the inadequacy of our present flooding predictions. The SLOSH model would give the State the ability to analyze the vulnerability of coastal areas to storm hazards, to identify the population and property at risk, and to develop evacuation plans for storms of varying intensities and following varying paths in the Atlantic Ocean. It would also help the State and coastal counties and municipalities to analyze land use plans and development proposals to prevent the construction of future structures in vulnerable areas. In addition, the data would lend credibility and drama to the State's efforts to educate the public about the potential for high water levels and damages. Most visitors to the shore and even many residents are unaware of the magnitude of storm hazards, and have not experienced a major coastal storm.

The first phase of the Delaware Bay Basin SLOSH model, which encompasses the southern New Jersey coast from the Manasquan Inlet around Cape May and up the Delaware Bay to the Delaware Memorial Bridge, was recently completed by the National Weather Service. The model also encompasses the State of Delaware and the eastern shore of Maryland. Refinement of the model in Phase II through the use of historical storm data from additional locations along the southern New Jersey coast and back bays is no~~w~~ required to derive reliable results from the model. The estimated non-NOAA cost of the required refinement of the Delaware Bay SLOSH Model is $105,000. New Jersey is seeking this money through a pending application to the Federal Emergency Management Agency (FEMA), with the assumption that NOAA will have adequate resources to match that money and complete Phase II.

New Jersey is also interested in seeing more specific models developed for our vulnerable ocean shorefront. While the Delaware Bay model will have a coarse resolution of two to three miles per grid point, we understand that NOAA has the capacity, if they have the funds, to prepare much finer models with half-mile grids. We would like to see such models developed for the area from Cape May Point to Atlantic City and from Atlantic City to the Manasquan Inlet. We would also be interested in pursuing the Raritan Bay/Long Island SLOSH model which would provide predictions for New Jersey north of Manasquan Inlet.

New Jersey is now actively engaged in coastal storm preparedness planning for the barrier islands of Atlantic County and for Ocean City in Cape May County, funded by the Federal Emergency Management Agency.

This is possible primarily because storm surges have been observed and recorded since 1911 at Atlantic City, and the hydraulically efficient inlets within that segment of the coast allow almost total exchange of tidal flows between the ocean and back bays. The assumption was therefore made that storm surge in the back bays would be approximately equal to that observed along the open coast.

If SLOSH data and maps had been available for this study, we could have developed evacuation plans, vulnerability analyses and hazard mitigation plans for several different storm scenarios and better defined and planned for the hazard due to storm surge. The planning effort could have included more coastal areas, and in particular, looked at the effect of mainland flooding on evacuation.

New Jersey is considered to have one of the nation's best Coastal Management Programs, yet our knowledge is obviously not complete. I know that other coastal states fact situations at least as serious. If the storm comes in the summer when our beachfront communities are packed with people from the northeastern states and Canada, everyone will then understand that we should have used every available, workable tool to predict and plan for the inevitable event. If we are able to continue to develop SLOSH models for New Jersey, we believe we will be able to substantially reduce the loss of life and perhaps of property as well.

Mr. SCHEUER. Thank you very much.

Dr. Mitchell—we are going to have a vote in a minute or two, so I'm going to ask each one of you a question and we'll have some more questions to ask you in writing. If you could be brief in your answers, my colleague and I could make this rollcall vote.

Dr. Mitchell, you mentioned in your testimony that Long Island and Cape Cod had a significantly higher risk of being struck by a hurricane than does New Jersey. Wherefrom the difference?

Dr. MITCHELL. Basically, they lie athwart the major hurricane tracks, whereas New Jersey parallels them. And so, you have about 6 or 7 percent annual probability in Long Island and Cape Cod; and you have, for most of the Jersey shore, about a 1-percent probability. Those probability figures are calculated for storms that occurred during this century. If you start going back into the 19th century, you begin to find there are other large storms which occurred, but the data is not sufficiently comparable to make a probability estimate.

Mr. SCHEUER. Thank you, Dr. Mitchell.

Ms. Ehinger, apparently NOAA isn't completing their SLOSH data, and they won't be able to unless they get more funding. If they don't get more funding, does your office have the capability of replicating that data on their own?

Ms. EHINGER. No; we don't. We are presently trying to get money to try to fund SLOSH through other avenues, and particularly FEMA grant requests. We are not able to do that, and we feel that it's essential that we do have it.

Mr. SCHEUER. All right. We will have some informal discussions with FEMA, as you know we're concerned with the fact that they aren't finishing the phase II—the phase II funding has not been forthcoming, and I think Congress will address that question with very great concern and attention.

I want to thank both of you for your fine testimony and for your patience in waiting through this morning.

We are going to suspend this hearing for about 15 minutes for us to go over and come back and answer this rollcall vote. So we'll suspend for 15 minutes, and then we'll complete the last panel, composed of Dr. Byron Spangler and Dr. E.J. Baker.

[Short recess taken.]

Mr. SCHEUER. OK, the committee will come back into session.

For our last panel, Dr. Byron Spangler, University of Florida; Dr. E.J. Baker, director, environmental hazards center, Florida State University.

Gentlemen, thank you for your patience. You have waited through a comparatively long morning. Your prepared testimony will be printed in full at this point in the record, and we would ask you, as we have asked other witnesses and as we're requiring ourselves to do, to keep your remarks to about 5 or 6 minutes, and then we'll have some questions for you.

So you can sum up your prepared testimony; but if you want to react to anything that you've heard this morning, either from up here or from any of the expert witnesses, by all means feel free to do so.

So Dr. Spangler, why don't we recognize you first and give you such time as you may need, up to about 5 or 6 minutes, and ask you to proceed at will.

STATEMENT OF DR. BYRON SPANGLER, UNIVERSITY OF FLORIDA

Dr. SPANGLER. Thank you, Mr. Chairman.

As a registered professional engineer, I have studied——

Mr. SCHEUER. What is your engineering specialty, if I might ask?

Dr. SPANGLER. Civil engineering.

Mr. SCHEUER. Civil engineering? Very good.

Dr. SPANGLER. And my specialty in structures, as a structural engineer, I have studied the damage resulting from several storms and I'm quite aware of the extent of that damage.

I appreciate the opportunity to appear before you today to discuss vertical evacuation and the role that it can play in comprehensive regional evacuation planning.

The remarks I make today are going to be based principally on a study that was recently completed that was jointly funded by the Florida Sea Grant Program and the Monroe County, FL civil defense group, that addressed itself to the evaluation of hurricane shelters.

The project was proposed, since there was no generally accepted method—or at that time, there was no generally accepted method—for the evaluation of shelters and the need was apparent. We had been encouraged to do it by several agencies, to determine the adequacy of the structures that are in areas that are subject not only to wind, but to storm surge.

The development and application of such a methodology is essential to comprehensive planning. People will not be able to evacuate; we've heard that already this morning—that is, the entire population will not be evacuated—so we must find some means for protection.

Now, this doesn't mean that we're going to be able to find perfect protection, but we need to find the best protection; and this is what I think we should do.

The project that I spoke of has resulted in a complete revision of the Monroe County shelter assignments, and we feel will result in better protection for the people in that area.

We find that the structures in the coastal areas are designed by architects and engineers that are not familiar with the damage that wind and waves can cause. The reason for this is that the codes require design for wind only; they do not address scour, the washing of the sand, or the wave forces or the storm surge.

Mr. SCHEUER. Scour?

Dr. SPANGLER. Scour.

Mr. SCHEUER. S-c-o-u-r?

Dr. SPANGLER. That's correct. That is the erosion of the sand from around the structure.

The structural frames and major wind-resistant components of what we call fully engineered buildings—those that are designed according to the code—will resist wind forces. We've had experience with that; in fact, they, in many instances, will resist even greater velocities than they were designed for. Some portions of the building, however, are subject to damage, and these are windows, doors, projections, and other components, and these have been known to fail below the design velocity.

Also, many problems have occurred as a result of improper construction practices. We can examine a building beforehand to determine its adequacy, but there are many things that we can't see. We can determine some faults, but everything that could exist that could cause a failure is not apparent.

The things that we have discovered and these points that I have brought out help to guide us in establishing the requirements for vertical evacuation shelters. Some of the things that we need to provide are structures that have a foundation that is not affected by scour, particularly those that are going to be built in the scour zone. The building must be designed to resist sliding and overturning, not only from the wind forces, but from the wave forces. We want to prevent flotation; the building must be heavy enough that it won't float.

Mr. SCHEUER. Excuse me. Did you say the building must be built to survive sliding?

Dr. SPANGLER. Sliding, that's correct.

Mr. SCHEUER. The building?

Dr. SPANGLER. The building itself——

Mr. SCHEUER. Will be sliding?

Dr. SPANGLER. There's a possibility that the building can slide if there's not sufficient resistance.

Mr. SCHEUER. And overturning?

Dr. SPANGLER. Sliding and overturning.

Mr. SCHEUER. Are you talking about a highrise structure?

Dr. SPANGLER. Yes.

Mr. SCHEUER. A highrise structure could be designed——

Dr. SPANGLER. To resist overturning.

Mr. SCHEUER. Oh, to resist overturning?

Dr. SPANGLER. Right.

Mr. SCHEUER. Good.

Dr. SPANGLER. That's correct.

Mr. **Scheuer**. Maybe you'd tell us how you do that. You've piqued my curiosity. I don't mean to interrupt you; I really want you to finish your testimony.

Dr. **Spangler**. Well, I'll mention that.

Mr. **Scheuer**. OK.

Dr. **Spangler**. The structural elements, of course, need to be tied together so that they work integrally and not cause a failure of the entire structure, and then the building supports and exterior walls must be capable of withstanding the impact of wind-driven and water-borne missiles, floating logs and propane gas tanks and things of that nature.

Doors, windows, and other openings must be capable of withstanding wind forces and wind-driven missiles. We saw an example of shutters being used in a building to afford that protection.

Structural and mechanical projections, like air-conditioning units and things of that nature, must be anchored well enough that, if they are torn loose, they won't damage the structure.

When we examined the buildings in Monroe County, we found that some of our suspicions were borne out that it's not possible to accurately predict the level of protection that most of the existing structures can provide. This is due to uncertainties relating to the design and construction practices that were used in these buildings. We found that plans are not available on these buildings, so we don't know just what the design was. Many of the plans that we found were incomplete. Many of the buildings were not built according to the plans. Buildings are not adequately maintained, and have lost the integrity that they had when they were initially built.

Despite these problems, there are things that we can do. We can examine a building, examine what is available, and make some determination as to a degree of level of protection. We can't guarantee that level; however, we can make an estimate of what we might expect that level to be.

NOAA's storm surge models play an important role in predicting the forces that will act on our shelters. We are concerned with scour, hydrostatic, or water pressure, hydrodynamic and wave forces that are going to act on our structures, and these are all highly dependent on the depth of water that our structure will be subjected to.

For this reason, it is crucial that storm surge levels be predicted as accurately as possible. If we overestimate the storm surge and level, then we're going to rule out some buildings that could be used as vertical evacuation shelters. If we underestimate, then we may create a problem for the lives of the people who may be using that shelter.

Even a relatively minor error in flood elevation predictions of 1 or 2 feet may mean the difference, then, between a safe and an unsafe shelter. We feel that NOAA's storm surge modeling efforts should be continued in order to provide us with this increased accuracy. Not only are the results necessary for completion of regional evacuation plans, but they are also necessary for evaluating existing structures that may be used as vertical shelters.

Moreover, both horizontal evacuation planning and design of vertical evacuation shelters are sensitive to the accuracy of the model.

Since one of the factors limiting the accuracy of models has been the lack of reliable field data of storm surge with which to calibrate them, efforts to collect such data and to complete existing models should also be continued.

That concludes my remarks. I thank you for permitting me to appear before you.

[The prepared statement of Dr. Spangler follows:]

STATEMENT BY

PROFESSOR BYRON SPANGLER

UNIVERSITY OF FLORIDA

ON VERTICAL EVACUATION IN COASTAL AREAS

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

AUGUST 9, 1984

My name is Byron Spangler. I am a Professor of Civil Engineering at the University of Florida in Gainesville, Florida. I am a registered professional engineer in the State of Florida, with a specialty in structural engineering. I have studied structural damage resulting from hurricanes and have just completed a project on the evaluation of hurricane shelters. I appreciate the opportunity to appear before you to discuss vertical evacuation and the role that it can play in comprehensive regional evacuation planning.

My remarks today are based on a research project jointly funded by the Florida Sea Grant College Program and Monroe County, Florida (which encompasses the Florida Keys). The project was proposed since there was no generally accepted method for assessing the structural resistance of hurricane shelters located in areas subject to hurricane wind, flood and wave forces. The development and application of such a methodology is essential to comprehensive evacuation planning since situations will arise where it will be impossible to evacuate everyone from vulnerable coastal areas; some will be forced to seek vertical refuge in buildings exposed to hurricane forces. The project has enabled Monroe County officials to revise their shelter assignments and will provide a methodology for other coastal communities to follow in evaluating their hurricane shelters.

As background, let me review the findings of several post-hurricane damage surveys. First, these surveys reveal that many of our coastal structures have not been designed and built to adequately resist the forces to which they have been subjected. Our building codes do not specifically require that wave scour and breaking wave forces be considered in design, even though many structural failures can be attributed to these factors. Structures are often designed by architects and engineers who are not aware of the magnitude of these forces and who design for wind only, as required by the code.

Second, the structural frames and major wind resisting components of fully-engineered buildings have in many instances proven to be capable of resisting wind loads slightly in excess of design wind loads. However, some portions of these buildings, particularly windows, doors and other such components, have been known to fail below design wind loading conditions.

Third, many failures have been the result of improper construction practices. In some cases, problems could have been detected beforehand had a thorough examination of the building been made. However, in some instances it would have been virtually impossible to detect the problems brought to light by the hurricanes.

These findings help to guide us in establishing the requirements for a vertical evacuation shelter. They are:

1. The building must have a foundation that is not affected by scour.
2. The building must resist sliding and overturning forces resulting from wind, flooding and waves.
3. The dead weight of the building must prevent flotation.
4. Structural elements must be tied together in such a fashion to resist all forces that they are subject to.
5. Building supports and exterior walls must be capable of withstanding the impact of wind-driven and/or water-borne debris.

6. Doors, windows and other openings must be capable of withstanding wind forces and wind-driven missiles. Shutters may be used to offer protection.
7. Structural and mechanical projections must be anchored to the structure to prevent damage to the building in the event of their loss.

The Monroe County study confirmed our suspicion that it is not possible to predict accurately the level of protection that most existing buildings can provide under hurricane conditions. This is due to the uncertainties relating to the design and construction of those buildings. We found, among other things, that: plans for some buldings are not available or are incomplete; some buildings were not built according to the plans; lack of maintenance of otherwise satisfactory buildings will reduce their utility as shelters.

Despite these problems, the uncertainty in the determination of structural resistance to hurricane forces can be minimized. This can be done by collecting as much information about the building and site as possible, inspecting them carefully and obtaining the best available predictions of storm forces at the site.

NOAA's storm surge models play an important role in predicting forces that will act on our shelters. Scour, hydrostatic, hydrodynamic and wave forces are all highly dependent upon the depth of flooding at the shelter site. For this reason it is crucial that storm surge levels be predicted as accurately as possible. If storm forces are overestimated, the use of a shelter will be lost under some conditions. If they are underestimated, the building may sustain unanticipated damages and occupants may be injured or killed. Even a relatively minor error in flood elevation predictions of one to two feet may mean the difference between a safe and an unsafe shelter.

NOAA's storm surge modeling efforts should be continued. Not only are the results necessary for the completion of regional evacuation plans, but they are also necessary for evaluating existing buildings or for providing more accurate design data for buildings to be used as vertical evacuation shelters. Moreover, both horizontal evacuation planning and the designation of vertical evacuation shelters are very sensitive to the accuracy of the model predictions. Since one of the factors limiting the accuracy of the models has been the lack of reliable field measurements of storm surge with which to calibrate them, efforts to collect such data and to improve existing models should also be continued.

Mr. Chairman, thank you again for the opportunity to testify. I hope my comments are useful to you.

Mr. SCHEUER. We are very happy to have you here, and we thank you for your testimony.

Dr. Baker.

STATEMENT OF DR. E.J. BAKER, DIRECTOR, ENVIRONMENTAL HAZARDS CENTER, FLORIDA STATE UNIVERSITY

Dr. BAKER. Thank you, Mr. Chairman.

First of all, I might say I'm tempted to reorient the thrust of my oral testimony to rebut about 50 percent of what Dave Murray from "Good Morning, America" told you about public response in hurricanes. I'll resist that temptation, though, and stick to what I have here prepared to summarize very briefly.

I think it's fair to make a distinction between at least two versions of what people call vertical evacuation. One is what I call vertical refuge, and the other is what people typically call vertical evacuation.

One proposal is to simply identify buildings which could be used in an emergency to shelter people that you've tried to evacuate by conventional means but, because you underestimated the time it was going to take or you underestimated the period of time that you were going to have for the evacuation, or you underestimated the severity of the storm, you get stuck in a situation where not everyone who needs to leave or to get away from the storm surge is going to be able to get off by conventional means.

I call that vertical refuge; and that is that you try everything you can, as if you didn't have the vertical shelters present, to try to get people out conventionally. But you have them on the shelf, so to speak, an ace in the hole in case you have to use them.

The other version is to say, "Look, we just don't want to try to evacuate 300 miles of coastline 24 hours early because of the large numbers of people we're moving," and so forth. "Therefore, let's wait until we're sure the storm is going to hit our area; and then we know we're not going to have time to get our people out by conventional means, but let's have them go up into vertical shelters."

Now, I think there's a lot of support for that first alternative, that is, the vertical refuge argument. The vertical evacuation argument, where you would use the vertical shelter in lieu of conventional evacuations, I think is far more controversial. I think that places are beginning to use the vertical refuge concept right now. The problem I see in it is that I think as communities start to implement the vertical refuge concept, they're going to move closer and closer to the vertical evacuation option. The reason is that if they know they have these vertical shelters on the shelf to be used as an ace in the hole, I think that they'll be less likely to ask people in their community to leave 20 or 24 hours early, knowing that the storm might not hit them.

So if you do that, then what you're really doing is moving toward what we're calling vertical evacuation anyway.

Now, let me summarize just quickly the principal arguments that are usually made both for and against vertical evacuation. I don't necessarily endorse all of these, but to be fair to the proponents of each, let me mention them.

First of all, for vertical evacuation. No. 1, conventional evacuation could require the early movement of large numbers of people over an area 300 miles or more wide due to the unpredictability of storm tracks, large populations at risk, and inadequate escape routes.

No. 2, 24 hours or so before landfall you don't know for sure what magnitude of storm you must evacuate for because storms can intensify quickly, and you might underestimate the number of people that you need to advise in evacuating.

No. 3, people can't be convinced to leave early enough for your conventional evacuation to work in some locations.

No. 4, most people, even from the 300-mile area, will leave unnecessarily making them unlikely to leave early or at all the next time they're told to.

No. 5, the economic cost of an evacuation involving 300-plus miles of coastline can be very high, including travel and lodging cost to evacuees, cost of operating public shelters, lost business transactions, and associated taxes and so forth.

No. 6, moving the numbers of people involved is dangerous, given the opportunities for traffic accidents.

And No. 7, vertical evacuation would pose less opportunity for predisaster looting.

Now, here are seven arguments against vertical evacuation.

No. 1, vertical evacuation has a high catastrophe potential. Subject to wave battering and scour, a large building could fail with loss of life of the large number of people that you are housing inside the building.

No. 2, there's no absolutely reliable way to certify safety. Just because buildings are designed properly doesn't mean that they're built properly.

No. 3, existing buildings would be of little use—if not because of certification problems relating to scour and battering, then because interior walls could fail if windows fail, thus subjecting the interior walls to the wind. And also, when the failure would subject occupants to wind-blown missiles.

No. 4, there are legal and equity questions still unanswered. For example, who is liable if the shelter fails? Who is liable if people suffer physical injuries for some other reason during sheltering? And who reimburses the building owners of private structures for damage to their structures caused by evacuees?

No. 5, building more high-rise structures to serve as vertical shelters would simply result in greater and greater populations at risk in hazardous areas, and make conventional evacuation even more difficult.

No. 6, although panic behavior is rare in natural disaster evacuations, there are certain circumstances in which panic is most likely to occur; that is, in close, crowded areas where an imminent threat is perceived and a need for urgent, adaptive response is believed to exist, like being in a crowded vertical shelter during a hurricane when the air conditioning and lights go out and the building creaks and sways, and you think you need to get out in a hurry.

No. 7, after a hurricane passes streets and roads, water, communications, sanitation, and electricity could be out of service on a barrier island which is cut off from the mainland by destroyed causeways. There could be scores of thousands needing evacuation after the storm, and many needing medical attention with no viable means of moving them.

So my recommendation is that if vertical evacuation is to be used, the structures should possess the following characteristics.

A, they should be designed for a category 4 or 5 intensity storm, depending on the local climatology of the area.

B, they should be located away from scour and likely overwash areas. Overwash areas are where the island would be cut by water mainly coming, I think, from the lagoonal side washing back into the sea.

C, they should be equipped with emergency electrical and water supplies and sanitary facilities.

D, they should stock first-aid supplies.

E, they should be staffed with trained personnel.

F, they should have adequate space.

G, they should have emergency communications capability.

H, they should be limited to structures not more than six stories in height to minimize the catastrophe potential involved.

And I, they should stock emergency food supplies for 1 to 2 days.

Basically, they should be designed to be operated as shelters, as well as being structurally sound.

I also think that planners in coastal areas ought to be more optimistic about being able to get people to evacuate early by conventional means than they are. You see, most of our hurricane experience in terms of where people—we've done studies of what people have done in hurricanes—has been in the Gulf of Mexico area. And so I'm not sure how thoroughly these are going to apply to the North Atlantic coast, but certainly I can say with a great deal of confidence that in the gulf coast, where most of our hurricane activity has existed for the past 20 years or so, people respond to urges from public officials to evacuate. But they don't evacuate until public officials tell them to.

What I'm mainly concerned about in terms of decisionmaking and response in a disaster is not so much what the public is going to do, but what public officials are going to do or what they're not going to do. I think the thing that they probably need more help with than anything else is deciding when to advise their local populace to evacuate.

Thank you, sir.

[The prepared statement of Dr. Baker follows:]

TESTIMONY

Issues Concerning Vertical Evacuation and Hurricane Response Decisions

Earl J. Baker
Director, Environmental Hazards Center
Florida State University
Tallahassee, Florida

August 9, 1984

U.S. House of Representatives Committee on
Science and Technology
Natural Resources, Agricultural Research and Environment
Subcommittee

Hearings on Hurricane Storm Surge Research

Issues Concerning Vertical Evacuation and Hurricane Response Decisions

Earl J. Baker
Florida State University

One of the most agonizing questions facing public officials in densely populated coastal areas concerns what to do when their areas are threatened by a hurricane. Recent studies have documented and quantified what many people had feared: To safely evacuate everyone at risk to a major storm, people in some locations might need to begin leaving more than 20 hours before arrival of the storm. At that time, however, the storm's landfall location, its severity, and even its time of arrival are largely unknown. Do you order an evacuation which will probably be "unnecessary," or do you wait for a better indication of the storm's likely behavior -- information which might come too late to leave time for a safe evacuation of all those at risk?

Because neither option is particularly attractive, the concept of vertical evacuation has gained in interest. Briefly, the vertical option proposes the short-term sheltering of people at risk to storm surge in buildings in the surge-prone area but built substantially enough and with high enough floors to accommodate people safely for a few hours until the storm passes.

Having described the concept in that manner, however, it must be pointed out that there are many variations to the basic idea. Vertical plans can differ with respect to at least the following criteria:

I. Structural Aspirations of the Buildings to Be Used
  A. Storm elements to be withstood
    1. External wind loads on structure
    2. External wind loads on windows and resistance to missiles
    3. Interior wind loads on interior walls
    4. Storm surge
    5. Wave battering
    6. Wave uplift
    7. Wave scour
    8. Some combination of the above
  B. Intensity of storm to be withstood

II. Location of Structures to Be Used
  A. Beachfront
  B. Lagoonal side of islands and barriers
  C. Mainland
  D. Some combination of the above

III. Sheltering Functions of the Buildings
  A. Physical refuge only
  B. Physical refuge, first aid kits, bottled water
  C. "B" plus trained staff, emergency generators, and communications

IV. Ownership of Buildings
  A. Public
  B. Private
  C. Both

V. Method for Certifying Safety of Buildings
  A. Existing structures
    1. Storm or shelter worthiness ascertained by inspection of builder's plans
    2. Storm or shelter worthiness ascertained by on-site inspection and testing
    3. Storm or shelter worthiness ascertained by historical performance
  B. New shelters built to vertical shelter specs

VI. Intended Portion of Population-at-Risk to be Housed in Vertical Shelters
  A. All or most
  B. Only those unable to evacuate safely by conventional means

VII. Public Information
  A. Public made aware of vertical option before threat
  B. Public not made aware of vertical option until conventional evacuation impossible

The point behind the listing is that if we're going to talk about the pros and cons of vertical evacuation, we have to recognize that there are a lot of different versions of vertical evacuation and each might have different pros and cons. Using the criteria listed above we can construct literally thousands of versions.

Perhaps the most significant of the criteria is the next to last: the intended portion of the population-at-risk which would be sheltered in vertical facilities. Some proponents of vertical evacuation advocate its use as a "refuge of last resort." That is, you get as many people out as you possibly can via conventional evacuation and have vertical shelters "on-the-shelf" in case it becomes obvious during the course of an evacuation that everyone at risk isn't going to be able to evacuate conventionally before the storm arrives. For the sake of labelling I call that vertical refuge. A minority of the population-at-risk would be so sheltered.

The other extreme would be to replace conventional evacuation with vertical evacuation almost totally. Instead of beginning the movement of substantial numbers of people 20 hours or so before possible arrival of hurricane conditions or the cutoff of evacuation routes, you would wait until you were relatively sure the storm was going to hit your area, say, eight hours before arrival of the storm. That would leave time for precious little evacuation by conventional means, so almost all of the population-at-risk would be housed in vertical facilities. This extreme case I call vertical evacuation.

In enumerating selected pro's and con's of vertical evacuation, I will address this more extreme version although many of the arguments are more general. There are two reasons to concentrate on this more extreme case:

1. Most people agree in principle that in difficult to evacuate areas some sort of vertical refuge option be available in case conventional evacuation fails. Thus, the refuge version is less controversial.
2. If a community has a vertical refuge plan, it will probably move further toward vertical evacuation. That is, officials will employ conventional evacuation plans less radically (e.g., not ordering very early evacuation if they have a vertical ace-in-the-hole).

With those points in mind, a number of commonly expressed arguments for and against vertical evacuation are presented below.

Arguments For Vertical Evacuation

1. Conventional evacuation requires the early movement of large numbers of people over an area 300 miles or more wide, due to the unpredictability of storm tracks, large populations-at-risk, and inadequate escape routes.
2. Twenty-four hours or so before landfall you don't know for sure what magnitude of storm you must evacuate for. Storms can intensify quickly.
3. People can't be convinced to leave early enough for conventional evacuation to work.
4. Most people leaving from the 300+ mile area will leave "unnecessarily," making them unlikely to leave early or at all the next time they're told to.

5. The economic cost of an evacuation involving 300+ miles of coastline can be very high (travel and lodging cost of evacuees, costs of operating public shelters, lost business transactions and associated taxes, etc.).
6. Moving the numbers of people involved is dangerous, given the opportunities for accidents.
7. Vertical evacuation would pose less opportunity for predisaster looting.

Arguments Against Vertical Evacuation

1. Vertical evacuation has a high catastrophe potential. Subject to wave battering and scour, a large building could fail.
2. There's no absolutely reliable way to certify safety. Just because buildings are designed properly doesn't mean they're built properly.
3. Existing buildings would be of little use, if not because of certification problems relating to scour and battering, then because interior walls could fail if windows failed. Window failure would also subject occupants to missiles.
4. There are legal and equity questions still unanswered: Who's liable if the shelter fails? Who's liable if people suffer physical injury for some other reason during sheltering? Who reimburses building owners for damage to their structures caused by evacuees?
5. Building more high-rise structures to serve as vertical shelters would result in greater and greater populations at

risk in hazardous areas and make conventional evacuation more and more difficult.

6. Although panic behavior is rare in natural disaster evacuations, there are certain circumstances in which panic is most likely to occur: in closed, crowded areas where an imminent threat is perceived and a need for urgent adaptive response is believed (like being in a crowded vertical shelter during a hurricane when the air conditioning and lights go out and the building creaks and sways);
7. After a hurricane passes, streets and roads, water, communications, sanitation, and electricity could be out of service on a barrier island which is cut off from the mainland by a destroyed causeway. There could be scores of thousands needing evacuation and many needing medical attention with no viable means of moving them.

Conclusions and Recommendations

1. If vertical evacuation is to be used, structures should possess the following characteristics:
    - A. Designed for category 4 or 5 intensity;;
    - B. Located away from scour and likely overwash areas;
    - C. Be equipped with emergency electrical and water supplies and sanitary facilities;
    - D. Stock first-aid supplies;
    - E. Be staffed with trained personnel;
    - F. Have adequate space;

   G. Have emergency communications capability;
   H. Be limited to structures not more than 6 stories in height to minimize catastrophe potential;
   I. Stock an emergency food supply for one to two days in case storm stalls after occupancy begins or for post-impact period.

2. Structures in coastal communities should be inventoried to ascertain the capabilities of existing buildings, identification of best candidates for use now, for upgrading, or for non-use.
3. Planners and public officials should be more optimistic about public response in conventional evacuation:
   A. Tell people to evacuate and they will;
   B. Wait to tell them to evacuate and they'll wait;
   C. Minimize the "cost" of their evacuating;
   D. Understand that the great majority will evacuate next time they're advised to, even if they leave unnecessarily this time.
4. After hazard and vulnerability analyses have been completed and evacuation times calculated, the greatest remaining need by local and state authorities is a decision system. Most state and local officials don't understand forecast uncertainties well enough to make well-informed decisions about when and whether to evacuate. They need assistance with this task in order to make best use of the evacuation study findings.

5. **SLOSH and SPLASH outputs should be used in public information brochures to help people understand whether their home would be flooded in various hurricanes. This is the single most important piece of information people can receive during the pre-threat period.**

Thank you for the opportunity to share these ideas with you.

Mr. SCHEUER. Why don't you take another minute or two to tell us where you disagree with David Murray?

Dr. BAKER. I think he's basically too pessimistic about public response, particularly with respect to the probability. We've conducted two studies, one after Alicia, to see how probabilities affected peoples' response to Alicia, and one also that was more hypothetical in Pinellas County, FL, around St. Petersburg before the probability system was implemented. And essentially, there is no evidence to suggest that probabilities, in and of themselves, do anything to inhibit public response.

Mr. SCHEUER. That's interesting.

What types of studies, Dr. Baker, do you think would be necessary to determine the adequacy of existing structures as vertical refuges? What would these studies cost?

Dr. BAKER. In terms of the structural aspects, I simply can't answer that. You'd be better off asking Dr. Spangler.

Mr. SCHEUER. All right.

Can existing buildings be modified to serve as vertical refuges?

Dr. BAKER. Well, let me back off on all this and simply say that I think that studies need to be done to determine the extent to which they can be.

Mr. SCHEUER. Right.

Let me ask you, Dr. Spangler, what kind of studies would we have to make to determine the adequacy of existing structures as vertical refuges, and what kind of modifications would have to be made and more or less what that would cost per person or per dwelling unit or per square foot or whatever?

Dr. SPANGLER. Mr. Chairman, that was the type of study that we made in Key West. We need to, as I said, examine the plans if they're available; and we need to examine the building and determine everything we can about the way the structure was designed and the way it was built. Once a structure is built it's very difficult to see where the steel is in the concrete, for example, or to know how deep into the ground the foundation or the piling was driven, or how the members are connected together.

So really, you have to make some assumptions as to the design and as to the type of builder you have in the area. How dependent can you be upon the reliability of the contracting industry?

Now, we found after Hurricane Eloise and Panama City Beach that there were many faults with the way the construction was carried out. Piling was misplaced; steel was left out of the concrete—many things that we found that would contribute to the failure of a structure. So it's difficult, really, to assign a true level of safety to a building because of the fact that we don't know what went on.

Mr. SCHEUER. Then you don't know whether the buildings were built according to the plans and specifications? Without tearing the building apart, leveling it?

Dr. SPANGLER. That's correct. Now, there are some nondestructive tests we can make, and we did carry out some of these in Key West to determine whether or not there was horizontal steel in the walls, for example, that would offer support. We can determine that if it was specified. In one case, we were told by one of the workmen on the job that it was not in place. We can go in and find these things out.

But generally, there are many things that we cannot determine.

Mr. SCHEUER. What kind of costs apply to such studies? Are they very expensive?

Dr. SPANGLER. Oh, it depends on the type of building, but I would say that it would run between $1,500 for a small building to probably $5,000 or $6,000 for a major structure.

Mr. SCHEUER. OK. All right. I thank you both very much. It's been a long morning, and you've shown a great deal of patience and fortitude, and you've given us very interesting and thoughtful and stimulating testimony. We thank you.

The meeting is adjourned.

[Whereupon, at 1:01 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

APPENDIX

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September 11, 1984

Honorable James H. Scheuer, Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment
388 House Office Building Annex II
Washington, D.C. 20515

Dear Mr. Chairman: Jim

I applaud your Subcommittee's efforts on hurricane storm surge research.

Although I was unable to participate in your hearing on this subject, I would appreciate your including my statement in the hearing transcript.

Thank you and with kindest regards, I am

Your friend
Sincerely,

Jack Brooks
JACK BROOKS
Chairman

Enclosure

STATEMENT OF CONGRESSMAN JACK BROOKS
SUBMITTED FOR THE RECORD IN CONJUNCTION WITH NATURAL RESOURCES SUBCOMMITTEE HEARING ON HURRICANE STORM SURGE RESEARCH

I appreciate the opportunity to provide testimony in connection with the Subcommittee's hearings on hurricane storm surge research. This issue is of crucial importance not only to my own Texas coastal district, but to all of the Nation's coastal regions.

The hurricane risk faced by coastal residents has increased substantially over the last 20 years. Rapid growth of population along the coast has strained the ability of some areas to evacuate in a timely manner when faced with a hurricane. The problem is compounded by the nature of the storms. Hurricanes are fickle. Exact landfalls are difficult to predict, and consequences of miscalculations are grave.

We must be willing to explore a variety of strategies to enhance the ability of coastal residents to escape harm from hurricanes. The efforts of government must be cooperative and thorough, with officials at all levels concentrating their efforts toward obtaining solutions.

As you may know, my Committee on Government Operations is also committed to assuring adequate hurricane protection. Last year the Committee issued a report (House Report 98-557) based on extensive investigations and hearings. The Committee recognized the importance of the National Oceanic and Atmospheric Administration's (NOAA) computer models, which compute storm surge heights under hypothetical hurricane conditions, and simulation runs, which provide quantative estimates of the surge effects of dozens of potential hurricanes with differing paths and intensities.

The Committee found that NOAA has not received funding for completion of its program of providing computer models and simulations of hurricanes to areas which need and want them. The Committee, therefore, recommended that NOAA and the Federal Emergency Management Agency continue their efforts to obtain funds to allow the continuation of this program. With the Nation's coastal population continually increasing, these citizens are more vulnerable now to losses from hurricanes than at any time since the inception of modern forecasting techniques. Funding for this vital element of the overall hurricane response program is a small investment when weighed against potential damages.

I applaud your subcommittee's interest in this area and offer this Committee's cooperation in your efforts.

DON FUQUA (Fla.), Chairman

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Minority Staff Director

August 21, 1984

Louis O. Giuffrida, Director
Federal Emergency Management Agency
Washington, D.C.

Dear Mr. Giuffrida:

On August 9, 1984, the Subcommittee on Natural Resources, Agriculture Research and Environment heard testimony from Mr. Samuel W. Speck, Associate Director, State and Local Programs and Support, on hurricane storm surge research. In connection with his testimony, we would appreciate written responses to the following questions, to be included as part of the hearing record.

1. Please describe the role of the Federal Emergency Management Agency (FEMA) in funding use of the SLOSH model in hurricane evacuation studies.

2. Please identify each study funded in part by FEMA and indicate the level of FEMA's financial assistance for each study.

3. If the National Oceanic and Atmospheric Administration (NOAA) could not run the SLOSH simulations due to a lack of funds, would the hurricane evacuation studies funded partly by FEMA be deprived of SLOSH data? What would be the effect on the quality of studies done without the benefit of the SLOSH data?

4. Is FEMA aware of any areas in addition to the original twenty-two basins which should be the subject of a SLOSH study? If so, please identify those areas.

5. Please estimate the funds that would be necessary for FEMA to fund, at past levels, the remaining hurricane evacuation studies using the SLOSH model.

Please provide written responses to the above questions by September 10, 1984. The responses may be sent to the Subcommittee's offices at 388 House Annex 2, Washington, D.C. 20515. If you have any questions concerning these responses, please do not hesitate to call Michael Rodemeyer, 226-6980, of the Subcommittee staff.

Sincerely,

JAMES H. SCHEUER
Chairman
Subcommittee on Natural Resources,
Agriculture Research & Environment

JHS/mlr

Federal Emergency Management Agency
Washington, D.C. 20472

SEP 11 1984

Honorable James H. Scheuer
Chairman, Subcommittee on Natural Resources,
Agricultural Research and Environment
U.S. House of Representatives
Committee on Science and Technology
Suite 2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Scheuer:

This is in response to your letter of August 21, 1984, requesting written responses to questions dealing with the Federal Emergency Management Agency's Hurricane Preparedness Program. Enclosed are the answers to the questions you asked for entry into the hearing record.

If you need further assistance, please have a member of your staff contact the Office of Congressional Relations at 287-0400.

Sincerely,

Samuel W. Speck

Samuel W. Speck
Associate Director

Enclosures

1. Describe the role of the Federal Emergency Management Agency (FEMA) in funding use of the SLOSH model in hurricane evacuation studies.

There are two phases in the application and utilization of a SLOSH model for hurricane evacuation studies. Congress appropriated funds to the National Weather Service (NWS) for a 5-year program beginning in 1981 to adapt the generalized SLOSH model to selected bays and estuaries referred to as "basins." In phase one, twenty-two basins were selected for SLOSH adaptation by the National Hurricane Center. The adapted SLOSH model is then used by the National Hurricane Center for forecasting the expected level of the storm surge for flood warnings when a hurricane threatens to strike the area. Since Congress appropriated funds specifically for model adaptation, FEMA has not provided funding to support this phase one activity.

In phase two, areas of flooding and high winds are delineated from 200-300 computer simulations of hypothetical hurricanes having differing intensities. From these simulations, hazard and vulnerability analyses are made and the population at risk is determined. These data are then used to develop evacuation plans that contain the number of people to be evacuated, routes to be taken, and total time required to evacuate before onset of gale force winds. The phase two simulations, in addition to providing a valuable tool for hurricane forecasting, are essential to FEMA's hurricane preparedness program. For this reason FEMA has and is prepared to share with States and other Federal Agencies such as NOAA and the Corps of Engineers in funding portions of the phase two effort as necessary.

2. Identify each study funded in part by FEMA and indicate the level of FEMA's financial assistance for each study.

The following table identifies the hurricane preparedness study areas, the level of FEMA's financial assistance and the current study status.

Study Receiving Financial Assistance	Level of FEMA Assistance Thru FY - 84	Status
Tampa Bay, FL	$175,000	completed
Georgia Coast	133,000	"
Long Island, NY	130,000	"
South Florida	150,000	"
Galveston/Houston, TX	200,000	ongoing
New Orleans, LA	175,000	"
Tri-State (FL,AL,MS)	415,000	"
Hawaii	170,000	"
New Jersey	190,000	"
Puerto Rico/Virgin Islands	75,000	"
Beaumont/Port Arthur TX	114,000	"
Corpus Cristi, TX	190,000	"
Pamlico Sound, NC	55,000	"
Brownsville, TX/Matamoros, Mexico	55,000	"
Charleston/Myrtle Beach,SC	85,000	"

3. If the National Oceanic and Atmospheric Administration (NOAA) could not run the SLOSH simulations due to a lack of funds, would the hurricane evacuation studies funded partly by FEMA be deprived of SLOSH data? What would be the effect on the quality of studies done without the benefit of the SLOSH data?

There is a significant loss in quality of studies not based on SLOSH. Flooding areas for different intensity hurricanes cannot be determined as well as the number of people to be evacuated. Also, the estimate of the time needed to evacuate before the onset of gale force winds would be less accurate. If NOAA is unable to provide the simulations then FEMA would look for other sources.

4. Is FEMA aware of any areas in addition to the original twenty-two basins which should be the subject of a SLOSH study? If so, please identify those areas.

At the present time, FEMA is not aware of any additional basins to the original twenty-two which will require SLOSH.

5. Estimate the funds that would be necessary for FEMA to fund, at past levels, the remaining hurricane evacuation studies using the SLOSH model.

Based on the total cost of past studies FEMA's best estimate to complete the remaining 7 evacuation studies not yet started that require SLOSH simulations is $4,200,000.

DON FUQUA, Fla., Chairman

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Minority Staff Director

August 21, 1984

John Byrne, Administrator
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Washington, D.C. 20230

Dear Dr. Byrne:

On August 9, 1984, the Subcommittee on Natural Resources, Agriculture Research and Environment heard testimony from Dr. Neil Frank, Director of the National Hurricane Center, on hurricane storm surge research. In connection with his testimony, we would appreciate written responses to the following questions, to be included as part of the hearing record.

1. In 1980, the National Weather Service identified twenty-two "basins" to be the subject of storm surge studies using a new computer model entitled "SLOSH" (for Sea, Lake and Overland Surges from Hurricanes). Please describe the status of these studies for the original twenty-two basins and indicate when they will be completed.

2. Does NOAA have sufficient funds to complete both Phase I and Phase II of the SLOSH studies for the original twenty-two basins? If not, please provide an estimate of the funds that NOAA would need to complete the remaining work.

3. In addition to the original twenty-two basins, has the National Weather Service identified any other areas which should be the subject of SLOSH studies, or has NOAA received requests from any other areas for SLOSH studies? If so, please identify such areas.

4. What has been the average cost for Phase I and Phase II per project?

5. Has funding for any of the SLOSH projects been contributed by state, local, regional or federal agencies other than NOAA? If so, please describe such contributions.

6. What efforts has NOAA made to secure additional funding from non-federal sources for SLOSH programs?

Please provide written responses to the above questions by September 10, 1984. The responses may be sent to the Subcommittee's offices at 388 House Annex 2, Washington, D.C. 20515. If you have any questions concerning these responses, please do not hesitate to call Michael Rodemeyer, 226-6980, of the Subcommittee staff.

Sincerely,

JAMES H. SCHEUER
Chairman
Subcommittee on Natural Resources,
Agriculture Research & Environment

JHS/mlr

Questions/Answers on Hurricane Storm Surge Research

1. In 1980, the National Weather Service identified twenty-two "basins" to be the subject of storm surge studies using a new computer model entitled "SLOSH" (for Sea, Lake and Overland Surges from Hurricanes). Please describe the status of these studies for the original twenty-two basins and indicate when they will be completed.

The 5-year appropriation listed 20 basins to be covered by the SLOSH model. The funds were sufficient to add two basins to the list. Twenty of these twenty-two basins have been completed using the SLOSH program. The remaining two basins will be completed during FY 85. The SLOSH model is adapted to the particular basin, tested, and turned over to the National Hurricane Center (NHC). At the NHC, SLOSH can be run for real-time, operational surge forecasting as a hurricane threatens or computer simulations of hypothetical hurricanes.

The computer simulations of hypothetical hurricanes are used to prepare an "atlas" showing the simulated flooding produced by these storms. Atlases will be completed for 11 basins by the end of FY 84. Three flooding atlases will be compiled from these simulations -- Charlotte Harbor, Florida; Corpus Christi, Texas; and Sabine Lake, Texas.

2. Does NOAA has sufficient funds to complete both Phase I and Phase II of the SLOSH studies for the original twenty-two basins? If not, please provide an estimate of the funds that NOAA would need to complete the remaining work.

Phase I, preparation of the storm surge models, is funded through FY 85. Funding for Phase II, computer simulations and preparing atlases, was not requested in the original appropriation. NOAA has reprogrammed funds to begin

Phase II and other Federal and state agencies have cooperated in providing some funding for the work. In order to continue Phase II work at the current level of production. NOAA will seek recovery of approximately half of the cost for doing Phase II work ($105K per basin), or continue the program over a longer period.

NOAA's total expenditure for Phase II this past year was $420K. The cost of completing Phase II for the original 22 basins is $3,010K ($2,310K for the remaining 11 complete Phase II efforts plus $700K to complete atlases for the 7 basins where simulations have been finished). NOAA will seek to recover half of this cost ($1,505K).

3. In addition to the original twenty-two basins, has the National Weather Service identified any other areas which should be the subject of SLOSH studies, or has NOAA received requests from any other areas for SLOSH studies? If so, please identify such areas

Other areas which could be considered for SLOSH application are:

Apalachicola, Florida
Atlantic City, New Jersey
Cape May (Southern), New Jersey
Ocean City, Maryland
Virginia Beach/Norfolk/Sandbridge, Virginia)
Myrtle Beach, South Carolina
Honolulu, Hawaii
Cape Canaveral, Florida
Crystal River, Florida
Vermilion Bay, Louisiana
Hawaii (2-4 basins in addition to Honolulu)
Puerto Rico (3 basins required)
Galveston, Texas*
Tampa Bay, Florida*
Lake Pontchartrain, Louisiana*
Portland, Maine
Penobscot, Maine

The ability to conduct SLOSH efforts depends in part on the states' abilities to being evacuation studies.

---

* Revisions of existing SLOSH basins.

The list of basins contains: (1) entirely new areas, not covered by an existing SLOSH model, (2) highly populated areas within a relatively coarse SLOSH grid, and (3) areas that would benefit from revisions to an existing SLOSH model. NOAA has not received any specific requests from other areas to participate in SLOSH studies.

4. What has been the average cost for Phase I and Phase II per project?

The average cost for Phase I has been $120K per basin. (NOAA received $2,640K between FY 81 and FY 85 and will have completed 22 basins by the end of FY 85.)

The average cost of Phase II is approximately $210K per basin. Two complete Phase II basins per year can be done with our existing staff. Current funding is $420 per year, with the Phase II cost per basin as $210K.

5. Has funding for any of the SLOSH projects been contributed by state, local, regional, or Federal agencies other than NOAA? If so, please describe such contributions.

Congress has funded all work associated with Phase I. Some funds have been contributed by other agenceis for Phase II:

Basin	Amount $(K)	Agency
o Lake Pontchartrain, LA	33	FEMA/State Disaster Agency
o Galveston Bay, TX	15	State Disaster Agency
o Charlotte Harbor, FL	8	Corps of Engineers (COE)

o Corpus Christi Bay, TX	15	State Disaster Agency
o Mobile Bay, AL (Tri-State Study)	70	FEMA/CoE
o Charleston Harbor, SC	41	FEMA/State Disaster Agency
o Pamlico Sound, NC	105	FEMA/CoE/State Disaster Agency
o Laguna, Madre, TX	15	State Disaster Agency

6. What efforts has NOAA made to secure additional funding from non-Federal sources for SLOSH programs?

While NOAA has focused its efforts to secure funding from Federal sources, contacts have been made with the states through the NOAA Office of Coastal Resources Management which administers a grant program. The NHC has worked very closely with various state officials describing the program and explaining the funding requirements for Phase II studies. In addition, we have made SLOSH presentations at hurricane conferences attended by various state officials, and we have frequently discussed the program informally with state officials. We are continuing to explore these and other avenues to secure funds.

SLOSH - A HURRICANE STORM SURGE FORECAST MODEL

Chester P. Jelesnianski, Jye Chen, Wilson A. Shaffer, and Amikam J. Gilad*

Techniques Development Laboratory
Office of Systems Development
National Weather Service, NOAA
Silver Spring, Maryland 20910

Abstract

The National Weather Service has developed a hurricane storm surge model, SLOSH, for real-time surge forecasts as a hurricane threatens. The model is being applied to 22 basins, covering most of the Gulf of Mexico and Atlantic coastal areas of the United States. Recently, the model has been used as a tool for hurricane evacuation planners to delineate areas of potential hurricane flooding.

1. Introduction

SLOSH--which stands for Sea, Lake, and Overland Surges from Hurricanes--is a numerical-dynamical computer model designed to forecast hurricane storm surges. The model was designed in the National Weather Service's Techniques Development Laboratory for "real-time" hurricane forecasting. The storm surge--a significant increase in water level accompanying a storm--has long been known as the major threat to life from a hurricane. In one incident alone, storm surge from the 1900 hurricane resulted in from 5000 to 6000 deaths in the Galveston storm.

Tide gage observations taken during a hurricane's passage show that the storm surge lasts, typically, about 6 hours. A sample tide gage report taken during a hurricane event is shown in Fig. 1 with the forecast astronomical tide removed. Of course, a very large, slow-moving hurricane will produce significant surges for a much longer period of time. To emphasize the threat posed by the surge, consider that the surge from Hurricane Camille in 1969 reached 24 feet!

A 5-year program to adapt the SLOSH model to 22 basins--or areas of coverage--along the Gulf of Mexico and Atlantic coasts began in FY 1981. The basins, shown in Fig. 2, were developed roughly in their order of vulnerability to hurricane storm surges.

2. The SLOSH Model

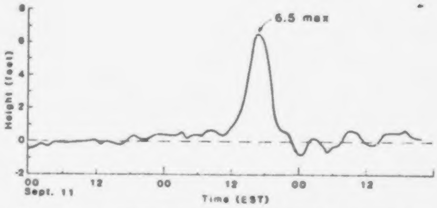

Figure 1. Typical storm surge record, formed by removing predicted tides from a tide gage record. The record shown was taken during Hurricane Donna, 1960, at Buzzards Bay, Massachusetts.

The SLOSH model is two-dimensional, covering part of the continental shelf, inland water bodies and terrain. The equations of fluid motion are solved numerically, incorporating finite amplitude effects but not the advective terms from the equations of motion. SLOSH uses a time-history bottom stress (Platzman, 1963; Jelesnianski, 1967), corrected for finite amplitude effects. At any given point, the computed surge is designed to reproduce the time-history of a long-period gravity wave--the surge as shown in a tide gage hydrograph or stage record. Short period phenomena, such as wind waves and their associated "run-up", are ignored.

With the exception of the Lake Okeechobee basin, all of the SLOSH basins use a polar grid, such as the one shown for the Lake Pontchartrain/New Orleans basin in Fig. 3. This polar grid allows a fine mesh in the primary area of interest. One advantage of this grid is that boundary conditions are imposed far from the area of interest.

On each of the model's gridpoints, a value of terrain height or water depth is supplied, thus tailoring the model to a specific basin area. Literally hundreds of maps (USGS quadrangle maps, NOS bathymetric charts, and various types of plats) are used to specify these values. The model allows for the overtopping of barriers or impeding the flow of water. Such barriers, significant with respect to grid size, include dunes, levees, spoil areas, natural ridges, reefs, and various man-made structures. The model also treats sub-grid size flow through cuts between barriers; channel flow; and chokes and expansions along rivers.

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*Mr. Gilad is employed by Marine Environments Corporation and works under contract with the National Weather Service.

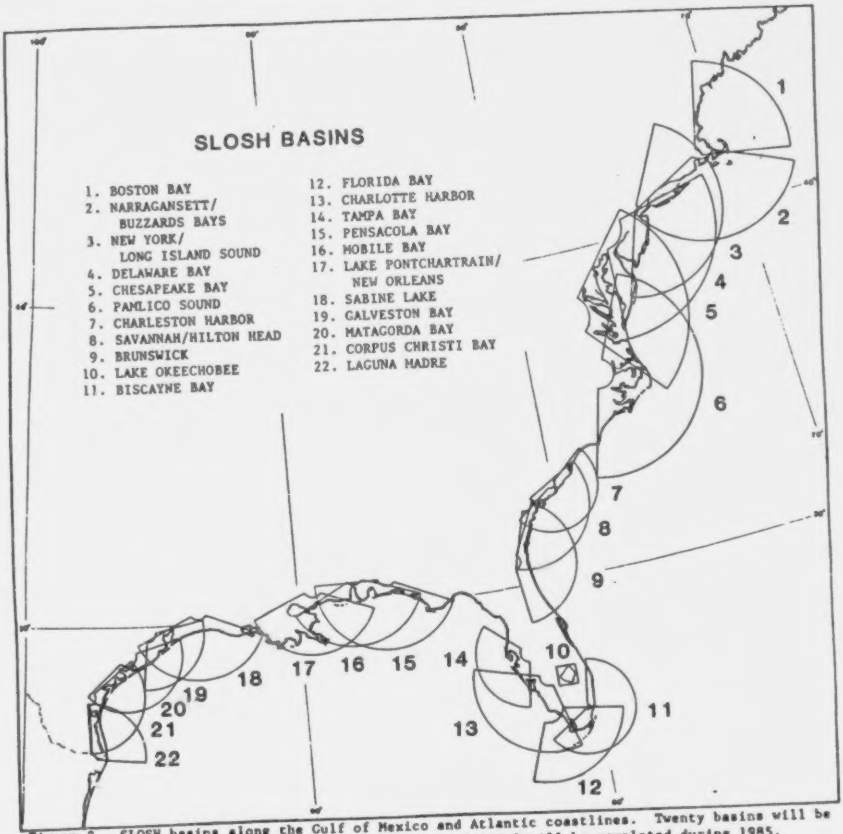
SLOSH BASINS
1. BOSTON BAY
2. NARRAGANSETT/ BUZZARDS BAYS
3. NEW YORK/ LONG ISLAND SOUND
4. DELAWARE BAY
5. CHESAPEAKE BAY
6. PAMLICO SOUND
7. CHARLESTON HARBOR
8. SAVANNAH/HILTON HEAD
9. BRUNSWICK
10. LAKE OKEECHOBEE
11. BISCAYNE BAY
12. FLORIDA BAY
13. CHARLOTTE HARBOR
14. TAMPA BAY
15. PENSACOLA BAY
16. MOBILE BAY
17. LAKE PONTCHARTRAIN/ NEW ORLEANS
18. SABINE LAKE
19. GALVESTON BAY
20. MATAGORDA BAY
21. CORPUS CHRISTI BAY
22. LAGUNA MADRE
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Figure 2. SLOSH basins along the Gulf of Mexico and Atlantic coastlines. Twenty basins will be completed by the end of this fiscal year. Basins 8 and 9 will be completed during 1985.

As the forecast proceeds, if water overtops barriers, then water spills into and is stored in areas behind the barriers. Model computations are turned on for newly wetted grid squares. Likewise, as water recedes after the storm, computations are turned off on dried grid squares. Water penetrates inland until impeded by other barriers or naturally rising terrain. It is possible for a hurricane to produce massive inundation across low lying terrain, extending many miles inland.

Imbedded within SLOSH is a hurricane wind model. For a computational run of SLOSH for a given hurricane event, the user must supply simple, time-dependent meteorological parameters. These are: position (latitude and longitude) of the hurricane, central pressure, and storm size (distance from storm center to the maximum wind). These inputs are entered at 6-hour intervals, beginning 48 hours before landfall and ending 24 hours after landfall. In the event the hurricane does not make landfall, the time of the storm nearest to the basin's defined origin is used instead of landfall time. Note that wind is not an input parameter. The SLOSH wind model produces a vector wind field throughout the basin by balancing forces according to the meteorological input parameters.

3. Model Accuracy

We attempt to simulate flooding from historical hurricanes that affected a basin, to verify the SLOSH model. This is done wherever sufficient observational data are available to define the hurricane to the needed precision and

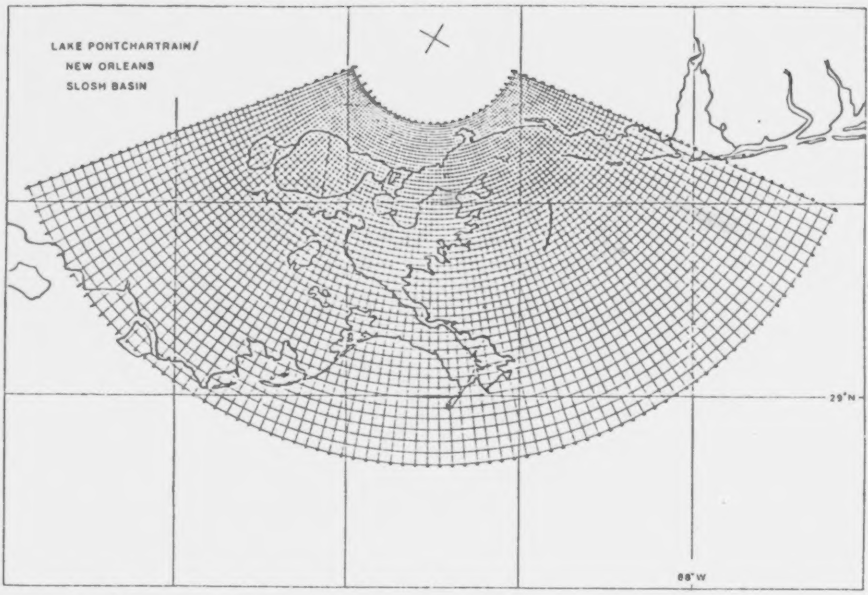

Figure 3. Example of the polar grid used by SLOSH, allowing fine resolution in the area of interest. The region of coverage is the Lake Pontchartrain/New Orleans area.

to adequately describe the storm surge at various locations within the basin. Surge data consist of tide gage observations, staff records, and high water marks. High water marks are the least accurate due to contamination by wave action and inadequate damping or overdamping of the water levels by the structure. Often high water marks vary by 20% for two locations separated by less than a mile.

Before a SLOSH simulation, the hurricane's track is determined as precisely as possible. We've found published "best fit" tracks are frequently not sufficiently accurate to pinpoint the hurricane's track and landfall. Even after a meticulous study, there are often ambiguities and imprecise data which compromise the desired level of detail. In addition to the track, we estimate as precisely as the data allow, a hurricane's radius of maximum wind and its central pressure. These are the same parameters required to make a real-time forecast using the SLOSH model.

In Fig. 4, we show the combined results of several simulations done for several basins. The error is generally within ± 20% for the significant surges, with a few observations falling outside that range. A total of 542 surge observations were used to develop this figure. These observations were taken throughout the area affected by the surge--around the maximum surge, at the storm's periphery, and along inland water bodies. Note that the tide gage data are limited to the lower observed heights; tide gages frequently fail during major surge events.

The SLOSH model is not "tuned" for a particular geographic location, but uses "universal" specifications for such constants as the model's drag coefficient, bottom stress, etc. This allows us to adapt SLOSH to any geographical location, whether or not it has ever experienced a hurricane, and if verification data is nonexistent, and have confidence in the model's computations.

4. Extended Uses of SLOSH

Although SLOSH originated as a forecast model, it has recently been used as a tool to delineate areas of potential hurricane flooding along the coast. With this information, an evacuation planner can identify areas for evacuation, determine which highways can be used for evacuation routes, and site shelters in areas not flooded or cut off by a hurricane.

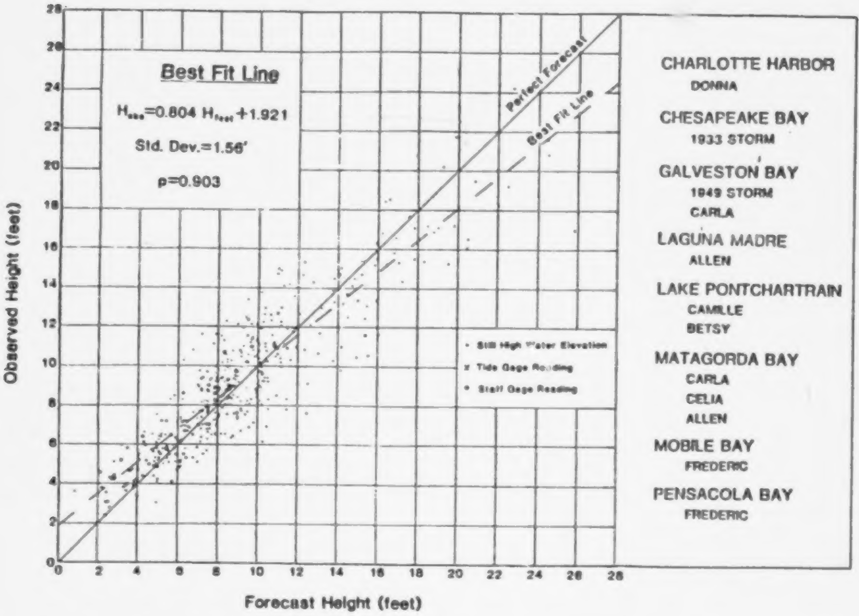

Figure 4. Observed surge heights versus surge heights forecast by the SLOSH model for nine storms in eight basins. A total of 542 tide gage, staff gage, and high water mark observations are shown with the corresponding SLOSH forecast. Generally, the model is within ± 20% for significant surge heights.

To find a region's potential for storm surge flooding, a large number of hypothetical storms are simulated to impact the area, with the flooding due to each one archived. These storms are varied in intensity, size, and landfall point along climatologically likely tracks. Typically, 300 such storms are simulated in a basin. This number is sufficient to highlight critical hurricane paths that may pose excessive flooding in an area.

A spinoff of the simulations is an "atlas" of flooding within a basin. This atlas comprises displays of flooding for each storm run for the vulnerability analysis. As a hurricane threatens the coast, a National Weather Service forecaster can turn to the atlas, match his forecast hurricane (path, size, and intensity) to one already in the atlas, and get an approximation of the flooding due to that storm. However, it is unlikely that any simulated hurricane will match precisely the track of the approaching storm. By using several analogue hurricanes from the atlas, bounds on the expected flooding can be obtained.

The atlas also contains various composites of flooding which are of use to the forecaster. For example, areas flooded by a hurricane coming from a given direction, regardless of its landfall point, and having a given hurricane intensity, may be combined. This composite aids the forecaster by pointing out critical regions where flooding may be extreme.

4. References

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Meteorological Society, Boston, Mass.

J1.4

THE ROLE OF COMMERCIAL METEOROLOGOLISTS IN HURRICANE FORECASTING

Joel N. Myers, Ph.D.
President
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619 W. College Avenue
State College, PA 16801

I am pleased to have the chance to represent professional, commercial meteorologists and Accu-Weather, Inc. at this 15th Technical Conference on Hurricanes and Tropical Meteorology.

Accu-Weather and I have been in the position of forecasting tropical storms and hurricanes for individual clients and the media for the past 14 years. During that time we have developed a number of philosophies and strategies for communicating forecasts to the public. As some of you know Accu-Weather has a staff of 51 professional meteorologists and a total of more than 90 employees. Seven of our meteorologists have Masters or Ph.D.'s in meteorology. We have people who hold the designation of Certified-Consulting Meteorologist and AMS seals for radio and television.

One of our first major experiences in broadcasting tropical storm information to the public came with Tropical Storm Agnes in 1972. More than 72 hours before Agnes struck Northeastern Pennsylvania with devastating floods and quite some time before any official warnings were issued we said publicly on WARM Radio, which is the Accu-Weather affiliate in Wilkes Barre - Scranton, that "Agnes has the potential to bring serious flooding to Northeastern Pennsylvania, perhaps the worst floods in a hundred years." This was not a warning, but it was valuable information to those who listened because it sensitized people in the area to the possible danger and heightened their awareness over the next few days. In traditionally flood-prone areas some preliminary precautions might have been taken. As you know, tropical storm Agnes did bring very severe and serious flooding to Northeastern Pennsylvania three days later.

Now some people have argued that the only information on tropical storms and hurricanes that should be passed on to the general public and other interested people is information coming directly from the National Hurricane Center because such information is the official word and differing forecasts can be confusing or misleading. We do not subscribe to that view. Fortunately, as long as we have the American constitution protecting our free speech as citizens and professionals, that argument is moot.

We are not satisfied in this country with one television network, with one source of news, with one national newspaper, or with one economic opinion; nor should we be satisfied with one source of weather forecasts, and clearly the public is not. The public has different opinions, and a variety of tastes, and it can identify with different stations and different meteorologists. The listening, viewing and reading public has found that a certain source of information, whether it be a particular radio station, a newspaper or a certain weather service is more reliable as far as their interests are concerned. We live in an age of deregulation. The federal government has taken the lead in deregulating the airline industry, the railroads, the banking industry and many of the old line monopolies and semi-monopolies are being broken up. There has even been talk in recent months of breaking up and perhaps even selling off to private industry parts of the National Oceanic and Atmospheric Administration.

So why should the National Hurricane Center be the only source of information and forecasts on tropical storms and hurricanes? There is no question it would make their job easier and there is no question it would reduce controversy, but would the public get the best forecast information in every situation. I think not.

Would the people in this great nation be content with one economic forecast, one prediction of how inflation will do, how unemployment will do, where the economy will go? Would Americans be content with a single forecast for the stock market coming from a single agency within the federal government? Of course not! There are many private economists that regularly issue economic forecasts that are either in agreement with or at variance with government forecasts. This does not confuse the public as to where the economy is going. On the contrary, it actually strengthens the American economy by providing a variety of ideas for people to consider and select from. It allows a consensus to be formed. It allows a spectrum to be displayed. And from this variety of opinions comes great strength. All of the economists have to be on their toes, because they may turn out to be right or wrong or somewhere in between and that will affect their reputation and their credibility. Thus, all economists being cognizant of all the other forecasts that will be issued that will be in competition with theirs work extra hard to try and make their forecast the best that they can produce. Likewise, the general public and specific users of these forecasts very carefully consider many of the forecasts, and the marketplace decides the future of each prognosticator. When a forecaster's economic models go bad and his techniques fail and he starts predicting things incorrectly, people stop subscribing to him and they turn to the more successful economic forecasters, and the models continue to be refined.

Now, some of you might say that they are only forecasts. We are talking here about warnings -- warnings that involve life and death. Yes we are. But let's not lose sight of the fact that warnings are just forecasts and many are news events, and many economic forecasts involve the gain and loss of fortunes, some crops and in some cases even the gain or loss of life. Now if anyone could prove that we could save just one life by having a single source or one official oracle of hurricane forecasts, I would agree with the concept immediately. However, I doubt that point can be made. Actually, the National Hurricane Center is a good example of a well-run and effective government agency and it is managed by a very dedicated man, Neil Frank. Still the National Hurricane Center is not infallible. They are very good, but they are not infallible. On September 19, 1979, Accu-Weather meteorologists announced on KTRH, Houston that an unnamed tropical storm "in the Gulf of Mexico was likely to come ashore and bring torrential rains, perhaps in excess of 10 inches to the Houston area and the Texas Gulf Coast." We also warned of strong gusty winds and said that that combination posed a threat to life and property along the Texas Coast. At that time there were no tropical storm advisories in effect and there were no hurricane advisories being issued. There were no tropical storm watches and no warnings, yet several hours later this unnamed tropical storm came ashore dumping 10-20 inches of rain, damaging or destroying several thousand homes. There is a full page and a half of stories in the NOAA publication Storm Data and Unusual Weather Phenomena connected with the storm such as the following:

"A tug boat reportedly sank 10 miles south of Galveston during the high winds, but the crew was rescued."

"Tides of 4 to 5 feet above mean sea level inhibited drainage of creeks near Galveston Shore. In Corpus Christi tides of up to 6 feet above mean sea level were recorded. By morning Corpus Christi International Airport had recorded 7.83 inches of rain."

"Corpus Christi received the most damage in the county. Rainfall rates overwhelmed already swollen drainage facilities. 400-500 homes, many businesses and possibly 300 apartments received flood damage."

Here's another report -- "the rains totalled 13 inches at Aransas Pass from midnight to 10 a.m. on the 19th and 18 inches for the 24 hour period ending at 10 a.m."

"Winds associated with the low pressure area caused scattered property damage in the three counties. Gusts were measured at 53 miles per hour in Corpus Christi and an estimated 80 miles per hour at Aransas Pass."

Another report -- "Freeport in Brazolia County eventually received 23 inches of rain for a 48 hour total up to the 20th."

To repeat, this storm struck on September 19, 1979. Climatologically speaking, this storm came at the most preferred time of year to have tropical characteristics. I am sure most people would agree that this storm sounds like it had tropical characteristics. Yet, officially, this storm was not named. After the fact it was called "an unusual non-tropical low pressure system." I have not singled out this situation in order to criticize the National Hurricane Center or the Houston Office of the National Weather Service. I have a great deal of respect and admiration for both organizations. My point here is that we at Accu-Weather, as a private company and with the talent and expertise of the meteorologists who work for us, were in a position to spot a dangerous situation developing. We went on the radio and notified the people of Houston and surrounding areas. Later that day more than a dozen people died as a result of the severe weather accompanying this storm. Hopefully, some people were saved because they listened to our forecasts and information on KTRH. Notice I did not call them warnings. We do not issue warnings.

We are aware that some private meteorologists do issue their own warnings. In a recent memo Dr. Hellgren addressed this issue by saying "...inconsistent warning information, may confuse the general public. Dr. T. Michael Carter, a Senior Social Scientist on my staff, tells me that social scientists generally agree that multiple warnings with conflicting information delay response of the general public, while warnings which are consistent in content help to enhance public response. As you know, the National Weather Service (NWS) is given responsibility to provide severe weather warnings to the Nation, but there are no statutes to prevent anyone else from issuing warnings. I do not believe it is my role to bring before Congress, the American Meteorological Society (AMS), or the National Broadcasters Association a policy which would make warnings the exclusive domain of the NWS. I do believe we should strive to work with the media and private concerns so that warnings are consistent even if they come from more than one source. I expect in the coming years more private firms will show an interest in providing warnings depending, of course, on what the courts have to say about liability. In the meantime, it is important we do our best to coordinate and share information with private concerns and avoid the pitfalls of contesting who gives the best service."

"...as we look ahead to the rapidly expanding technological developments in meteorology and communications, I have two key concerns. First, our offices must set an example of providing our users with the best possible service. Second, I want our field offices to be diligent in working with private companies. This means coordinating, sharing information, and establishing a working relationship. If we can accomplish this, it will be a credit to the NWS, and our citizenry will be well served."

We endorse these ideas and embrace them.

In fact, we do not believe private companies should issue their own warnings.

Our philosophy is as follows, and I believe that this should be the philosophy and working pattern of all commercial professional meteorologists. All official watches or warnings coming from the National Hurricane Center should be passed on to the public immediately and they should be continually part of any forecasts --

and this is done with all Accu-Weather forecasts. If there is a Hurricane Watch or a Hurricane Warning or Special Statement in effect we include it as part of the Accu-Weather forecast. However, as professional meteorologists, we reserve the right to comment on it. If we disagree professionally with some aspect of the official warning, we say so. If we agree with it, we say so. If a watch or a warning is not in effect and yet we believe severe or damaging weather could occur, we do not feel any restraint, in fact we feel an obligation, to pass that information along to our clients as part of our forecast.

We believe there have been a number of storms, perhaps as many as a dozen over the past 14 years, in which we at Accu-Weather have played a significant role in saving life and property with our timely forecasts. The unnamed storm of June 19, 1982 along the North Carolina Coast and the unnamed storm of October 24-25, 1982, which caused winds of 90 miles per hour in Norfolk, are two such examples.

With Hurricane Alicia, this past August, Accu-Weather meteorologists again did a very accurate job. From first forecasting the probable development of the storm into the first tropical storm of the season, well before any official bulletins or advisories were issued, to forecasting landfall to within seven miles of its final location and within 30 minutes, 18 hours in advance.

The public was listening to our information and depending upon it. This confidence has been built up over a period of ten years. Arbitron surveys of the period during Alicia's approach and battering of Houston, show that an amazing 47% of the Houston listeners remembered specifically that they were listening to KTRH, and station officials tell me they assume that had there been a measurement of the full market place that figure would be substantially higher -- possibly 70%. This research shows that these people tuned into KTRH because they had confidence in what the station personnel and Accu-Weather meteorologists were saying.

As professional meteorologists who are the source of weather forecasts and information for more than 150 radio and television stations and major newspapers across the country, we are most interested in cooperating to the fullest extent possible with the National Weather Service at the local, regional and national level and, of course, with the National Hurricane Center. Increasingly, professional broadcast meteorologists have taken over the job of communicating weather forecasts and information to the public. It is important that these professionals work as closely as possible with the National Hurricane Center and other official agencies. This would reduce the chance for confusion and misunderstanding in crucial situations. This requires cooperation and mutual respect.

The bottom line of all of this is service to the public. It is my belief that virtually all forecast meteorolgists, whether in the private or public sector, are most interested in issuing the most accurate forecasts that they can and are interested in saving lives and property whenever and wherever severe weather threatens. We need to work together to harness the energies and talent of the private and public sector so as to maximize this goal.

JOEL N. MYERS, President
ELLIOT ABRAMS, Sr. Vice President
JOSEPH P. SOBEL, Sr. Vice President
EVAN A. MYERS, Sr. Vice President
MICHAEL A. STEINBERG, Vice President

619 W. COLLEGE AVE.
STATE COLLEGE, PA 16801
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ACCU-WEATHER & ALICIA

Sunday, August 14, 4:10 PM

Accu-Weather meteorologists noticed the rapid intensification of thunderstorms in the Gulf of Mexico, a circulation starts to show. They immediately call KTRH in Houston and go on the air telling of possible tropical storm development in the central Gulf of Mexico. There were no official advisories and no tropical storm bulletins about the beginnings of soon-to-be Hurricane Alicia.

Monday Morning

Accu-Weather meteorologists announce on KTRH and other Gulf Coast Accu-Weather affiliates that the development toward a tropical storm continues. The National Hurricane Center says that they will probably send a hurricane reconnaisance plane into the area to see if there are any tropical characteristics.

Monday early afternoon

Accu-Weather meteorologists begin referring to the storm as a "tropical system" and indicate that the storm looks like it will develop into a full-fledged tropical storm. The National Weather Service is still investigating.

Monday, 3:35 PM

Accu-Weather meteorologists say that based on radar and satellite information and other data available, the storm appears to have already achieved tropical storm status.

Monday, 6:00 PM

The National Hurricane Center officially calls the storm a tropical storm for the first time and names it Alicia.

Tuesday morning

Accu-Weather meteorologists say that Tropical Storm Alicia will probably achieve hurricane strength Tuesday afternoon. The National Hurricane Center makes no such prediction.

Tuesday, 3:35 PM

Accu-Weather meteorologists believe the storm has already achieved hurricane strength despite the fact that this has not been confirmed by official hurricane advisories.

Tuesday, 6:00 PM

The National Weather Service indicates that the storm is now Hurricane Alicia. Accu-Weather metetorologists now predict that the storm will reach land sometime between Wednesay night and Thursday morning between Matagorda and Freeport -- a prediction which in the end missed by only 6 miles.

Wednesday morning

Accu-Weather meteorologists predict that the storm will increase in intensity with maximum winds reading 110-120 mph before coming ashore. They further predict Alicia will come ashore in the wee hours of Thursday morning, maintaining their prediction of landfall between Matagorda and Freeport.

Wednesday, late morning

Accu-Weather meteorologists say on KTRH that the storm has apparently achieved wind velocities in excess of 100 mph, although the official advisories are still quoting 85 mph.

Accu-Weather meteorolgists are now zeroing in on the landfall position and feel that Hurricane Alicia will come ashore near Freeport, TX, in the wee hours of Thursday morning -- a prediction that was uncannily accurate. Meanwhile the National Hurricane Center still has hurricane warnings flying over a vast area, from Monroe, LA, to Corpus Christi, TX.

Wednesday, 2:00 PM

A National Weather Service spokesman in Houston says the hurricane is now headed much further south and expected to come inland at Port Lavaca, which is 122 miles south of Houston. Accu-Weather sticks to its guns that the hurricane will come ashore between Matagorda and Freeport, with Freeport the most likely point.

Wednesday, 4:00 PM

Accu-Weather meteorologists now say they confidently believe the eye of the storm will come ashore at Freeport between midnight and 3 AM on Thursday, with 3 AM the most likely time.

ALICIA CAME ASHORE AT 2:30 AM, SIX MILES NORTH OF FREEPORT.

ACCU-WEATHER NEWS®

VOLUME 1, NO. 6
Evan A. Myers, Editor
Beverly Grothey, Production Manager
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SEPTEMBER, 1983

ACCU-WEATHER AT RTNDA

Some of Accu-Weather's top corporate personnel will be at the RTNDA convention in Las Vegas from September 21st through the 24th. Among those from Accu-Weather will be Joel Myers, President, and Joe Sobel and Evan Myers, Vice Presidents.

Accu-Weather will be displaying its exciting new graphics at booth #50 on the exhibit floor at Caesar's Palace. Please come by to visit us.

ACCU-WEATHER AND ALICIA ON TARGET ALL THE WAY

Sunday, August 14, 4:10 PM

Accu-Weather meteorologists noticed the rapid intensification of thunderstorms in the Gulf of Mexico. They immediately call client station KTRH Radio in Houston and tell of possible tropical storm development. There were no official government advisories or tropical storm bulletins about the beginnings of soon-to-be Hurricane Alicia.

Monday morning

Accu-Weather meteorologists announce on KTRH and other Gulf Coast Accu-Weather affiliates that the development toward a tropical storm continues. The National Hurricane Center says that they will probably send a hurricane reconnaissance plane into the area.

Monday, early afternoon

Accu-Weather meteorologists refer to the storm as a "tropical system" and indicate that it will develop into a tropical storm. The National Weather Service continues to investigate.

Monday, 3:35 PM

Accu-Weather meteorologists advise that based on radar and satellite information and other data available, the storm appears to have already achieved tropical storm status.

Monday, 6:00 PM

The National Hurricane Center officially calls the storm tropical and names it Alicia.

Tuesday morning

Accu-Weather meteorologists say that Tropical Storm Alicia will achieve hurricane strength Tuesday afternoon and eventually effect the Texas Coast. The National Hurricane Center makes no such prediction.

Tuesday, 3:35 PM

Accu-Weather meteorologists state that they believe the storm has already achieved hurricane strength despite the fact that this has not been confirmed by official hurricane advisories.

Tuesday, 6:00 PM

The National Weather Service indicates that the storm is now Hurricane Alicia. Accu-Weather metetorologists publicly predict that the storm will reach land sometime between Wednesday night and Thursday morning between Matagorda and Freeport, Texas.

Wednesday morning

Accu-Weather meteorologists predict on-the-air that the storm will increase in intensity with maximum winds reaching 110-120 mph before coming ashore. They further predict Alicia will come ashore in the wee hours of Thursday morning.

Wednesday, late morning

Accu-Weather meteorologists say on KTRH that the storm has apparently achieved wind velocities in excess of 100 mph, although the official advisories still say 85 mph. Accu-Weather meteorolgists zero in on the landfall position and state that Hurricane Alicia will come ashore near Freeport, TX, in the wee hours of Thursday morning. Meanwhile the

Continued Back Page

ACCU-WEATHER, INC. 619 W. College Avenue - State College, PA 16801 - (814) 237-0309

Alicia — continued

National Hurricane Center still has hurricane warnings flying over a vast area, from Monroe, LA, to Corpus Christi, TX.

Wednesday, 2:00 PM

A National Weather Service spokesman in Houston says the hurricane is now headed further south will come inland near Port Lavaca, which is 122 miles south of Houston. Accu-Weather sticks to its guns that the hurricane will come ashore near Freeport.

Wednesday, 4:00 PM

Accu-Weather meteorologists now say they confidently believe the eye of the storm will come ashore at Freeport between midnight and 3 AM Thursday, with 3 AM most likely. ALICIA CAME ASHORE AT 2:30 AM, SIX MILES NORTH OF FREEPORT.

Dear Joel:

I just had to write to express how pleased we are with your Accu-Weather service at KTSA.

Your more accurate weather forecasting, the professional air sound of your forecasters and the excellent level of weather service to the station just has to take some of the credit for the development of more audience captivating programming here at KTSA! Not to mention your service's assistance in both ratings and additional revenue.

For this reason, I would highly recommend Accu-Weather to any broadcaster who is fortunate enough to secure your services!

Sincerely,
J. Paul Huddleston
News & Operations Director
KTSA/KTFM, San Antonio, TX

Dear Joel:

Thanks to Accu-Weather, KTRH listeners got a 2-day jump on what became Hurricane Alicia.

It was Accu-Weather's report Sunday, August 14th, that alerted KTRH of a storm system in the Gulf that could develop into something more.

Not only did our listeners have this early warning, but it gave my staff the opportunity to plan emergency coverage and to roll into action, even before Alicia was (officially) declared a tropical storm.

I'm proud to have the entire Accu-Weather staff on my side. Evan Myers, Joe Bastardi and the rest of your meteorologists helped us through long and tensed moments, as KTRH tracked Alicia's progress across Galveston and Houston.

One final point in the tracking of Alicia, she made landfall less than 7 miles from Accu-Weather's original estimate.

You're the best, thanks for making us the best.

Sincerely,
Ed Shane
Program Director
KTRH-Radio, Houston

Dear Joel:

Now that we've all recovered from a less than restful weekend with Hurricane Barry, I feel it is important to give credit where credit is due. That is, of course, to your Accu-Weather Meteorologists.

Barry seemed to be one of the most unpredictable storms we've seen in a long time. But both Mike Hoffman and Dan Kottlowski were on top of every movement the erratic storm made...often well ahead of the National Weather Service. With Mike and Dan's continuous on-air explanation of what was happening and what we could expect out of Barry, our station and Accu-Weather received considerable acclaim for keeping the people of the Rio Grande Valley informed about our first South Texas Hurricane since Allen of 1980.

Both Mike and Dan deserve special credit for their coverage of Hurricane Barry. Mike for staying with us into the wee hours of the morning...only to return before noon so we could provide continuous coverage of the storm. And to Dan, for not being upset when I called him at home at 2:30 Sunday morning, asking him to come in and help us out (he was on the air with us within 90 minutes). In fact, it seemed as if Dan would have been upset if I would not have called him. That dedication is what puts Accu-Weather on top of the weather forecasting profession. Thanks to all of you, we are Rio Grande Valley's number one weather station.

Once again, thank you very much...to all of you.

Sincerely,
Tim Smith
Chief Weathercaster
KRGV-TV, Weslaco, TX

HAVE YOU GOTTEN YOUR ACCU-WEATHER GRAPHICS DEMO TAPE YET?
CALL ACCU-WEATHER TODAY